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LEPTOCHILUS AND GENERA CONFUSED WITH IT

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THIRTY-TWO PLATES AND FIFTY-TWO TEXT FIGURES

The reaction from the purely descriptive attitude in fern taxonomy, exemplified by the genus *Acrostichum* of Hooker's Species Filicum and the Synopsis Filicum of Hooker and Baker, found its first general expression in the treatment of the Polypodiaceæ by Diels in the Natürlichen Pflanzenfamilien. Many of the natural genera found independent places in this work, but a large and unnatural genus *Gymnopteris* still survived. In Christensen's invaluable Index this was practically unchanged except in name, becoming *Leptochilus*. The purpose of the present study is the recognition of the natural groups still combined here in the two great works just referred to, and a monographic treatment of some of the natural genera. It is nearly a quarter of a century since I began to recognize these natural groups, describing *Christiopteris*, reviving *Lomagramma*, and accepting *Hemigramma*. I was singularly slow to comprehend the identity of *Campium;* and, until this was done, any comprehensive analysis was impossible. It is not presumed that this presentation is perfect, but it is confidently believed that it is a closer approximation to nature than were any of its predecessors.

A work of this kind has two somewhat distinct phases. One is acquaintance with the ferns. As the words reasonably may be understood, I know the Philippine species well; which is a particular advantage in work with these groups, because several

fern of southern India. As it happens, Presl was flattered enough to accept this as a correction, and even to support it by the wild guess that "Asia" on Hügel's label (Fée's fern) was "Verisimiliter quoque Manila." Otherwise, Presl's specific name might be retained, on the hypothesis that he knew as well as Fée that is was not subject to transfer, but, still liking the name, administered it again, de novo. To deny this possibility is to maintain that this one nameless plant could not be given a name which could be given to any other nameless plant in the genus.

Being acquainted with the Indian fern described by Fée, from the examination of specimens confidently referred to it, and this identification checked by a photograph of the Vienna specimen cited and seen by Fée, and knowing neither this fern nor any near relative of it in the Philippines, but knowing in the Philippines ferns in another genus that are superficially very much like it, I have grave misgivings as to this generic type. I have tried in vain to clear this question, by inquiry as to Presl's type specimen, understood to be in Prague.

There is no question as to Presl's idea of his genus *Campium*, nor as to any other of the five species he cites. Before, in, and after his time, a genus was a group, as a whole, properly described as a whole, never expected to rest, for validity or for identification, upon any single species. Under the circumstances, I would be unable to justify any other course than the choice of *Campium*, as the name of the large genus that includes all of the species to which Presl gave the name, except, perhaps, the one which he chanced to mention first; but, to secure the exact embodiment of the generic idea that modern workers have found desirable and eventually necessary, I propose that *Campium costatum*, with the proper Wallich type, be recognized as the standard species of the genus.

Although none of the other generic names is in question, a multitude of nomenclatorial difficulties and puzzles will demand attention in the course of this work. I have disposed of them as best I could. To make revision easy in the future, in case my decisions are questioned, I am presenting the literature, rather completely. As practically always happens in a work of this kind, I have felt obliged to increase the number of species demanding recognition. As likewise usually happens, I regard some hitherto accepted species as identical with one another. Additions and reductions will of course continue in the future. To facilitate such activity, I have tried to assemble here the most

critically important literature—in particular, the original diagnoses of the species. These require no more space than would new descriptions. Where the diagnoses are very defective, I have added to them, but I have not thought it necessary that I repeat them in English. Where I suspect synonymy, I quote the later-published diagnosis, without transfer of name. Any successor able to decide that he has, or has not, to deal with a synonym, will find the requisite literature references assembled here—he has only to be sure that he knows the ferns. Where reasonably certain of synonymy, I let this be the time for a name to retire; citing it sometimes, but not usually using space to repeat synonymy already published in the Index Filicum. Original diagnoses are authoritative in text, as is never true in any like sense of descriptions by later writers; and, as a rule, they also give the type localities and, explicitly or by easy inference, show where type specimens can be consulted. While correct assignment to genus is the item of first importance in the description of a species, the generic diagnosis has no corresponding importance. In assigning a species to a genus, the essential problem is the recognition of affinity. Conformity to a generic diagnosis is important to exactly the extent that it may establish affinity; in the cases of the great majority of the genera of ferns, conformity to original diagnosis hardly does this at all.

Beside the recognition of the genera, the compilation of the literature, and the application of this to the ferns, and the description of new species, I have, in *Campium* (the only genus large enough to make the discriminataion of the species very difficult), facilitated their recognition by numerous drawings of the detail of the venation, and have had photographed all new species and a number of old ones not hitherto illustrated. The drawings, in the cases of species with large, pinnate fronds, all show the venation more or less in the middle of the acroscopic side of the larger, but not the basal, pinnæ. Therefore, they are fairly comparable. Some variation of the design occurs, of course, in all species; and the pattern is necessarily different where the pinna is more deeply cut, as it often is near the base, and where it is narrower, as near the apex.

In the direct preparation of this paper, I have had the excellent library facilities of the University of California, with occasional assistance from the John Crerar Library, Harvard and Stanford Universities, the United States Department of Agriculture, and the California Academy of Science. The ferns studied are (1)

in my own herbarium; (2) in the collections deposited at the University of California by Dean Merrill; (3) large collections loaned by the Royal Botanic Gardens (Kew) and (4) the Gray Herbarium; (5) the Praeger collection of the California Academy of Science; (6) the ferns of these genera in the herbarium of the Missouri Botanical Garden; and (7), received shortly before the paper was completed, one hundred seventy specimens from the United States National Herbarium. For this generous and various assistance I wish to express grateful appreciation to those who have rendered it. The personal assistance of Dr. Carl Christensen is acknowledged at the end of this treatise.

Except as error is responsible for the inclusion of species (as *Leptochilus celebicus*, which is a *Dryopteris*), the Oriental genera represented in *Leptochilus* of the Index Filicum may be distinguished as follows:

Key to the Oriental genera represented in Leptochilus of the Index Filicum.

1. Scandent or epiphytic.
   2. Fronds simple and entire, thin ..... *Leptochilus.*
   2. Fronds cleft or divided, coriaceous ..... *Christiopteris.*
   2. Fronds compound, pinnæ or pinnules articulate ..... *Lomagramma.*
1. Terrestrial.
   2. Rhizome creeping ..... *Campium.*
   2. Rhizome short, more or less erect.
      3. Stipe scaly, not hairy ..... *Hemigramma.*
      3. Stipe and frond hairy ..... *Quercifilix.*

Of these genera, *Christiopteris*, *Lomagramma*, and *Hemigramma* have been accepted by Christensen, who abstains only as a matter of form from the transfer of their species. Nothing needs now to be added to my last statement on *Christiopteris*,[2] except to repeat that *C. copelandi* is not distinct from *C. sagitta*, and to question the transfer to his genus of *Polypodium cantoniense*. In the case of *Lomagramma*, also, all valid known species are already provided with proper names. The same is obviously true of *Leptochilus*, but its isolation has to be justified.

Genus LEPTOCHILUS Kaulfuss

Leptochilus KAULFUSS, Enum. Fil. (1824) 147.

A genus of polypodiid ferns, related to *Phymatodes*, as shown by the epiphytic habit, vestigial articulation of stipe to scandent, scaly but glabrescent rhizome, and reticulate venation with co-

[2] Philip. Journ. Sci. § C 12 (1917) 331.

pious and irregular free included veinlets ending in hyaline dots; further characterized by simple, entire fronds, the fertile onés narrowly linear, with acrostichoid fructification.

LEPTOCHILUS AXILLARIS (Cavanilles) Kaulfuss. Plate 1.

Acrostichum axillare CAVANILLES, Anal. Hist. Nat. 1 (1799) 101.

Acrostichum axillare caulescens, foliis sterilibus lanceolatis; fructiferis linearibus, ad sterilia subaxillaribus. *Anales pag. 101.*

El tallo crece como cinco pies, vestido de hojas estériles y fructíferas. Las estériles son lanceoladas, enteras, lampiñas, de seis pulgadas de largo con una de ancho y peciolos cortos. Las fructíferas son mas largas, de una línea de ancho, pecioladas, cuyos peciolos nacen de los de las estériles. El tegumento es muy angosto, y las cajitas ferrugíneas. Se cría en los terrenos secos de la isla de Luzón, donde lo vió el citado Née.—CAVANILLES, Descripción de las plantas, page 239.

This genus has had a career in the hands of pteridologists, more adventurous even than most of the genera of ferns with acrostichoid fructification. By 1846 it was already "nimis extensum" in Kunze's opinion. In the hands of Hooker and Baker and those under the sway of their prestige, it has of course been reduced to *Acrostichum*, or at least to *Gymnopteris*. From this dumping ground it was extracted with undue glory. In Christensen's Index, animated as it is with the spirit of phylogeny, *Leptochilus* is made to include ferns as diverse as *Hemigramma*, tectarid in origin; *Christiopteris*, probably matonioid; *Lomagramma*, remotely dennstaedtioid; a lot of unrelated American ferns; and several dozen more nearly related terrestrial species of its own part of the world.

Leptochilus itself is almost certainly related to the *Phymatodes* section of *Polypodium;* more especially, probably, to the group of *Polypodium myriocarpum.*[4] The tendency to lose the individuality of the sori is shown in this group by another offshoot, *Diblemma samarensis*. I have never seen juvenile specimens showing any peculiarity in their fructification, but atavistic fronds, partly sterile and partly fertile, are not rare; see Plate 1, *a*. From them, and from the development of the fruiting area of young fronds, it seems proper to conclude positively that this

[4] When dealing with a large group, and a clearly related small but more-specialized group of more-restricted range, there is a presumption, in the absence of evidence, that the latter is descended from the former. This was my first judgment as to the relationship of *Leptochilus* and *Phymatodes;* but I have some evidence, which requires further study, suggesting that they may have a joint source, in or near *Christiopteris*.

fern is not descended from others with elongate sori oblique to the costa; that is, from any fern that could be called *Selliguea*. Aside from habitat, texture, and venation, the ancestry of *Leptochilus* is betrayed also by the presence of an apparent joint at the insertion of the stipe on the rhizome. As to this, Presl[5] says flatly: "Frondes heteromorphae, glaberrimae, cum rhizomate articulatae."

The plant owes its specific name to the accident that in the specimens in the hands of Cavanilles the fertile fronds seemed to be borne in the axils of the sterile. What happens is that branch buds are borne in these axils, sometimes almost as regularly as in any flowering plant (Plate 1, *b*). These buds may form ordinary branches; and, as the old parts of the rhizome live long, the common result is a complicated mass of stems, all still connected. The most of these buds, however, remain very short, but produce a succession of leaves, usually one at a time, functioning quite as do the dwarf branches of *Larix*. By the activity of the dwarf branches, old parts of the rhizome continue to produce leaves, so that a plant commonly bears a very large number at all times.

The type locality is given as Luzon, "in dry places." It is commonly found in places not at all dry; for example, it is very common in Laguna Province, Luzon, near the line between land in cultivation and the forest, a zone subject, because of its humidity, to the bud rot of the coco palm. The species is found west to India, and east at least to the extremity of Papua, and preserves a notable uniformity throughout this range. Specimens from Kaiser-Wilhelms Land and Papua are more caudate than is common farther west, and a specimen from Siam has the lamina decurrent to the rhizome.

LEPTOCHILUS PLATYPHYLLUS Copeland, sp. nov. Plate 2.

L. frondibus subsessilibus ca. 30 cm longis, ca. 8 cm latis, brevi-acuminatis, supra basin ad 1–2 cm et ad basin abrupte ad stipitem 2–3 mm longum contractis; fertilibus 20–25 cm longis, stipitibus 5 cm longis exceptis, usque ad 1 cm latis, marginibus in herbario revolutis; aliter L. axillari similis.

Sumatra, *Hancock 61*, 1862. Type in the United States National Herbarium, No. 1277348.

The broad and almost sessile fronds are too far from the range of ordinary variation of *L. axillaris* to justify treating this as a form of that species.

[5] Epim. 183.

Genus CAMPIUM Presl

Campium PRESL, Tentamen Pterid. (1836) 238, emended to include *Dendroglossa* PRESL, Epimeliae Bot. (1851) 149.

A genus of polypodiid ferns, descended from that group in § *Selliguea* called *Colysis* by Presl, as shown by the terrestrial habit, seriate fronds, and atavistic forms which intergrade with *Polypodium selliguea* Mettenius; rhizome creeping, usually short; articulation of stipe vestigial or none; frond simple and without main veins (*Dendroglossa*), or with pinnately arranged main veins or pinnate, or rarely bipinnate; veinlets anastomosing irregularly, or regularly along the costa and main veins; free included veinlets wanting or few and irregular, rarely somewhat regular; fertile fronds contracted, usually much so, the fructification typically acrostichoid.

For this genus the oldest distinctive name is *Campium* Presl, Tentamen Pterid. (1836) 238; Epim. Bot. (1849) 169. To Presl's disgust, J. Smith presently (1841 and 1842) set up a genus *Cyrtogonium*, and Fée (1845) a genus *Heteroneuron*, both for the same group. All of these genera were intended to include only normally pinnate ferns, with distinct main veins. Various of the species sometimes or usually bear simple fronds, but the main veins still have their evident character.

Another group of these ferns, usually of quite distinct appearance, has simple, small fronds, and no strong, straight main veins. To these, Presl [8] gave the distinctive generic name *Dendroglossa*. "Maxime affine est hoc genus Selligueae, differt praeter habitum peculiarem venarum costaeformium absentia . . . . A Colysi differt illico frondibus dimorphis." It is unfortunate that more students have not had Presl's eye for affinity. His *Colysis membranacea*, of late construed as *Polypodium selliguea* Mettenius, is in fact so nearly related to his *Dendroglossa* that it is sometimes difficult to decide which genus is represented by an atavistic specimen of *Dendroglossa linnaeana*.

As to the habitat, Presl says, in the generic diagnosis, "Rhizoma in cortice arborum putrescente repens;" which is incorrect and hard to understand. His first species is *Dendroglossa normalis* (*Gymnopteris normale* J. Smith; Cuming pl. Phil. No. 326). The label of my specimen bearing this number has no note respecting the habitat, nor have any of the Cuming labels I have seen; but I know the fern very well, and have never

[8] Epim. Bot. (1851) 149.

found it except on rocky creek banks. As to his other species, *Dendroglossa lanceolata*, Presl says: "Habitat in argillosis ad terram." The fact is that these ferns are typically terrestrial and have a terrestrial ancestry, so far independent of that of *Leptochilus*, with which, therefore, they cannot be congeneric. How far back into the so-called *Polypodium* it would be necessary to go to find a common parentage for both groups, I have not tried to ascertain; and the question is irrelevant, because nobody would seek to combine in one genus the species with distinct sori and their descendants with acrostichoid fruit.

Presl's supposed genera, *Campium* and *Dendroglossa*, usually seem distinct and easily recognizable; but not always. *Dendroglossa* has typically linear fertile fronds and sterile fronds without evident main veins; but its range of forms extends, not merely in one direction to the production of widened fertile fronds with unmistakably selligueoid sori, but also in another to the production of exceptionally large and broad sterile fronds with correspondingly well-developed main veins. Whether or not Hooker [7] is correct in treating as a close relative of this plant one with deeply laciniate-pinnatifid fronds; the moment that main veins are developed, the essential condition for pinnate dissection is provided. This is not the only place in the group where the same line is broken over. *Leptochilus hydrophyllus* is a typical *Dendroglossa* if judged by the most of the material collected; but one exceptional frond, the largest, shows a correlated tendency towards strengthening the main veins. The line between *Dendroglossa* and *Campium* seems to be crossed independently in at least two places—from *C. lanceolatum* toward *C. decurrens*, and between *C. hydrophyllum* and *C. subsimplex*—wherefore, it cannot properly be maintained as a line between genera.

If the genus *Campium*, as here construed, is monophyletic, its most primitive component seems to be the Philippine form of *C. linnaeanum*, and the outside parent is very closely represented by *Polypodium selliguea*. This matter of recognizable parenthood is emphasized by repetition, because, as our knowledge of relationships grows complete, this becomes the most essential element of generic character—the other general consideration in determining what groups should be genera being convenience.

While the genus *Campium* as a whole is, for the present, delim-

[7] Sp. Fil. 5: 277.

ited with reasonable clearness and is perfectly recognizable by anybody fairly acquainted with these ferns, the satisfactory definition of some of the species is quite impossible. The following list and keys are, therefore, to be taken as expressing such judgment in the matter as I have at present. From India to Papua, there are species that are characteristically unstable. As two of the most rich in forms, as construed of late, have Philippine types, and vary in the Philippines as freely as is easily imaginable, a wealth of Philippine material is particularly valuable in their interpretation.

Key to the species of the section Dendroglossa.

§ 1. Fronds simple, entire, and without main veins .... § 1. *Dendroglossa.*
1. Sterile fronds small, under 7.5 cm long.
2. Fronds narrowed toward the base.
3. Sessile or nearly so ..... 2. *C. minus.*
3. Long-stipitate ..... 3. *C. minutulum.*
2. Base truncate or subcordate ..... 4. *C. dilatatum.*
1. Sterile fronds typically 10 cm or more long.
2. Sterile fronds sessile or nearly so.
3. Lanceolate ..... 5. *C. metallicum.*
3. Linear ..... 6. *C. wallii.*
2. Sterile fronds stipitate.
3. Base narrowed abruptly ..... 12. *C. hydrophyllum.*
3. Tapering to the base.
4. Stipe less than 6 cm long ..... 1. *C. linnaeanum.*
4. Stipe more than 10 cm long ..... 7. *C. lanceolatum.*
§ 2. Fronds pinnate or main veins conspicuous.. § 2. *Heteroneuron* (p. 349).

1. **CAMPIUM LINNAEANUM (Fée) Copeland, comb. nov. Plate 3.**

Leptochilus linnaeanus FÉE, Acrost. (1845) 87, pl. 47, fig. 2.

Frondibus sterilibus anguste lanceolatis, curvatis membranaceis, glabris, apice longe acuminatis, basi cuneatis, margine repando, petiolis squamosis; fertilibus longius petiolatis, linearibus utrinque acutis; rhizomate flexuoso, crasso, crassitie pennae columbae; sporangiis rotundatis, annulo 12 articulato, sporis ovoideis nudis.

Acrostichum lanceolatum, Linn. . . .

Habitat ad terram argilosam in Java (Zollinger).—V. S. in Herb. Jussieu et de Lessert.

Exsiccatum: Zollinger, no. 1441.

Dimensions: Frondes stériles, longueur, 16–18 centim., avec un pétiole de 5 centim. environ; largeur, 15 millim.=Frondes fertiles, longueur, 18–19 centim., avec un pétiole, qui a les deux tiers environ de cette dimension; largeur, 3 millim.—FÉE.

In further notes, Fée compares this with his *Leptochilus minor*, noting the paucity of free included veinlets in both, as compared, presumably, with his *L. lanceolatus*. Fée's citation

of Linnæus is most remarkable. Assuming it to be correct, why did he not transfer the Linnæan specific name, instead of, higher up on the same page, using that name for a different species? The clear fact is that the citation is not correct.

I believe the Mindanao fern, the subject of Plate 3, *b*, is correctly identified as this species, and that it is properly conspecific with the common Luzon fern shown on the same plate. Statements as to the range of this species, *Campium lanceolatum*, and *C. decurrens* may well be mistrusted.

As is the case with all of this group, the rhizome is slender, creeping on the ground or on rocks, commonly in moss, characteristically occurring on the banks of streams in mountain woods, at moderate altitudes. It is more or less persistently clothed, in the common Philippine fern, with narrowly lanceolate, long-acuminate scales, 2 to 3 millimeters long when intact.

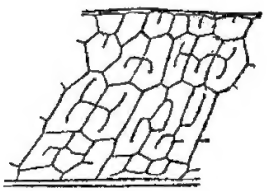

FIG. 1. *Campium linnaeanum* (Fée) Copeland, comb. nov.; Davao.

Typically, the sterile frond is a decimeter and upward in length, narrowed gradually and not very unequally toward both ends, six to ten times as long as broad, and borne on a stipe more or less 5 centimeters long, the lamina decurrent on the upper part of it. Fée's figures are good, but I include another because his are not generally accessible. The fertile frond is typically long-stalked, and hardly wider than filiform. The sterile frond is typically without straight main veins, but in exceptionally large or broad fronds there is always a tendency for the primary branches of the costa to straighten and become conspicuous. The veinlets anastomose freely, with few to many free included veinlets. Corresponding with the herbaceous texture, the areolæ are fairly large.

Another form, commoner in the Philippines (Plate 3, *a*), has the lamina decurrent almost, or rarely quite, to the rhizome, and its fertile frond tends to maintain some width of lamina. This fertile frond is rarely quite filiform, most commonly linear, rarely a centimeter or more in width; and these broader fronds always, at least when young, bear distinct, elongate, obliquely placed sori. Between such a form as this and Blume's *Grammitis membranacea*, *Polypodium selliguea* Mettenius, there might be an open gap; but it is occupied by *Polypodium fluviatile* Lauterbach, from the edge of a creek in Borneo. This and an unnamed Hainan plant differ from *P. selliguea* in being mod-

erately dimorphous. The transition from *"Polypodium"* to *Compium* is thus very completely bridged.

Gymnopteris dichotomophlebia Hayata, Icones Plantarum Formosanarum 4 (1914) 201, seems to be this commonest Philippine form with the fertile fronds very narrow. Hayata's description is very complete and accompanied by figures, and shows nothing distinctive except in the scale from the rhizome. As described and figured, this is imbricate-cordate and hardly acute. Such scales are known to me in the group only as they commonly and eventually lose their characteristic attenuate tips, with age and wear. This is described from Hainan, whence we have also the dimorphous *Polypodium* just mentioned. It is possible that Hayata's specific name should be applied to the Luzon plant.

2. CAMPIUM MINUS (Fée) Copeland, comb. nov. Plate 4, fig. 1.

Leptochilus minor FÉE, Acrostichum (1845) 87, pl. 25, fig. 3.

Frondibus sterilibus lanceolatis, basi attenuatis, apice obtusiusculis, longe petiolatis, glabris; fertilibus anguste linearibus obtusiusculis, longioribus; mesoneuro complanato; rhizomate repente; sporangiis brevissime pedunculatis, annulo 14 articulato, sporis ovalibus, laevibus.

Gymnopteris normale, J. Smith, Enum. fil., Cuming, in Journ. of Bot., Hook., mai, 1841.

Exsiccatum: Cuming no. 326.

Habitat in insulis Philippinarum (Cuming).—V. S.

Dimensions: Longueur des frondules fertiles, 9 centim., sur un centim. de largeur; des frondules stériles, 15 centim.; sur un millim. de largeur.—FÉE. (The fronds are certainly reversed in this statement of size.)

This description of a little fern with long-stipitate sterile fronds does not fit the common Philippine form with the fronds sessile or nearly so. Neither does it apply well to the specimens of *Cuming 326* in Hooker's, or Presl's, or my herbarium. The scant material in the Gray Herbarium is intermediate.

It applies better to a plant of northern India,[8] which is the following species. For these reasons, I [9] revived the name first given the Philippine species by J. Smith, and used by Presl, *Leptochilus normalis* (J. Smith). However, it has since become evident that there can be found in the Philippines specimens which conform to Fée's description, and that these are merely stipitate examples of the normally sessile fronds. They are rare

[8] See Hooker, Sp. Fil. 5: 277 (the accompanying drawing of a frond is from the Hooker and Thomson collection cited there).

[9] Philip. Journ. Sci. § C 3 (1908) 31.

near Los Baños, Laguna Province, Luzon, where the sessile form is common; but *Elmer 16728*, from Sorsogon, which adjoins Samar, distributed with my imperfect determination as *Leptochilus normalis*, has mostly stipitate fronds. Under the circumstances, I am forced to the conclusion that *Cuming 326* is all the same species, and that it must bear Fée's specific name, as the first to be accompanied by a diagnosis.

The little plants of Khasia and the Philippines are really not identical. The difference is not essentially in venation, as might appear from my drawings. The Philippine specimen drawn represents the extreme of absence of free included veinlets and of

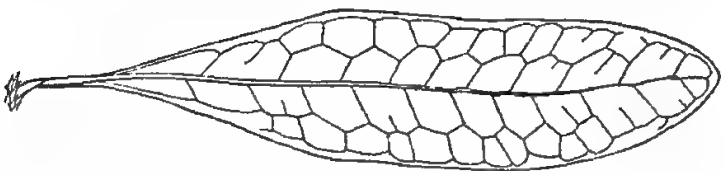

FIG. 2. *Campium minus* (Fée) Copeland, comb. nov.; a normal leaf from Los Baños, Laguna. Free included veinlets are usually much more numerous.

fine submarginal network, and I have Philippine fronds which in these respects are essentially like the Khasia specimen drawn; but the Philippine specimens are consistently shorter-stipitate, with relatively narrower and less-decurrent lamina. What is more significant, they have blacker, narrower, and more-toothed paleæ. The importance of this lies in the fact that in paleæ, as well as in frond form and stipes, the minute ferns of each region betray their affinity to the larger ferns of the same region, instead of to one another. Therefore, it requires no unreasonably fine discrimination to recognize these as specifically distinct, similar as they are in appearance.

3. CAMPIUM MINUTULUM (Fée) Copeland, comb. nov.

Leptochilus minutulus FÉE, Mém. 10 (1865) 8, pl. 31, fig. 2.

Les frondes stériles sont oblongues, obtuses, assez longuement pétiolées, a marge des lames sinuées; la lame fertile est presque lancéolée; les frondes sont portées sur un rhizome délié. Les frondes stériles ressemblent aux frondes stériles des *Craspedaria;* nous en donnons la figure, tab. XXXI, fig. 2, sous le nom de *L. minutulus*.—FÉE.

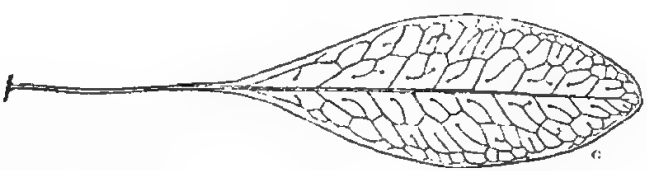

FIG. 3. *Campium minutulum* (Fée) Copeland, comb. nov.; Khasia, *Hooker and Thomson.*

This description is of a Khasia fern collected by Hooker and Thomson, and is to distinguish it from the Philippine *Leptochilus minor*. For a further comparison of the two, see the remarks under the preceding species. Gustav Mann has collected the same fern in about the same place, United States National Herbarium No. 329564.

4. CAMPIUM DILATATUM Copeland, sp. nov. Plate 4, fig. 2.

Rhizomate repente, 1–2 mm crasso, paleis minutis fuscis acuminatis vestito; stipitibus remotis, gracilibus, fr. sterilium 2–4 cm, fertilium fere 20 cm altis, nudis; fronde sterile herbacea, glabra, rotundato-oblonga, usque ad 4 cm longa et 3 cm lata, apice rotundata, basi truncata vel subcordata, margine integra vel undulata, costa infra apicem dissipata, venis primariis nullis, venulis irregulariter anastomantibus cum liberis inclusis; fronde fertile ca. 5 cm longa, anguste lineare.

Hainan, Kap Kao, altitude 100 meters, on rocks over river, *Eryl Smith 1446*, 1923. Type in the herbarium of the University of California, No. 234119.

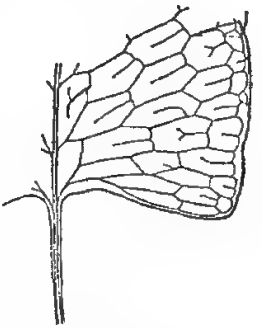

FIG. 4. *Campium dilatatum*. Copeland, sp. nov.; type.

Among the recognized members of the *Dendroglossa* group, this is sharply marked off by the broad sterile frond. *Polypodium cantoniense* Baker, as figured by Hooker,[10] suggests it strongly, but seems to differ essentially in the broader fertile frond, as well as in being coarser throughout. It is very probable that this is where it belongs. If so, Christ was far astray in transferring it to *Christiopteris*. Baker is silent as to its texture, which is a critical character; but *Christiopteris* has also very characteristic paleæ, not at all like those of this fern.

5. CAMPIUM METALLICUM, (Beddome) Copeland, comb. nov.

Gymnopteris metallica BEDDOME, Ferns Brit. India, Suppl. (1876) 26, pl. 390.

Fronds quite sessile 3–7 inches long up to nearly 1 inch broad of a deep shining metallic blue color, fertile fronds only soriferous towards the apex. Ceylon in dense moist forests on the Haycock mountain growing on rocks. This is intermediate between Wallii and true lanceolata and is, I believe, only a variety of the latter, it is a very beautiful plant.—BEDDOME.

[10] Ic. Pl. pl. 1685.

Beddome [11] adds that the main veins are often indistinguishable from the others, and omits his doubt as to the specific status. As he conceived his *Gymnopteris lanceolata*, or *G. variabilis*, as broad enough to include *Campium decurrens* and *Leptochilus axillaris*, the inclusion of other real species of *Dendroglossa* would not be surprising.

The sterile frond is rigidly chartaceous and remarkably opaque. The larger ones have, as Beddome's plate shows, a stipe, not more than 5 millimeters long. In the one specimen in the Gray Herbarium, the fertile frond has a filiform stipe about 15 centimeters long. The fertile "lamina" is itself less than 1 millimeter wide, and 12 centimeters long with a broken apex; it consists of a sterile costa, and just enough lamina to anchor the sporangia. The young rhizome bears dark, shining, clathrate, lanceolate-acuminate paleæ, with very minutely spiny margins. Under the microscope, the walls are chestnut and the contents colorless. The rhizome is 1.5 millimeters in diameter, bearing fronds about 1 centimeter apart.

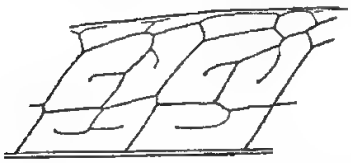

FIG. 8. *Campium metallicum* (Beddome) Copeland, comb. nov.

6. CAMPIUM WALLII (Baker) Copeland, comb. nov.

Acrostichum (*Chrysodium*) *wallii* BAKER, Journ. Bot. 10 (1872) 146.

Rhizomate gracili reptante paleis lanceolatis subsecundis vestito, frondibus segregatis sterilibus subsessilibus anguste ligulatis glabris membranaceis viridibus nullo modo squamosis obtusis margine obscure late repandulis basi cuneatis, maculis inter costam et marginem uniseriatis valde verticaliter elongatis vena unica centrali decurvata saepissime praeditis, frondibus fertilibus gracillimis filiformibus longe petiolatis.—BAKER.

Ceylon.

The sterile fronds are 20 to 25 centimeters long and 4 to 6 millimeters wide; fertile frond, 15 to 20 centimeters long, its stipe 8 to 15 centimeters. The narrow sterile frond, and consequent single row of areolæ on each side of the costa, distinguish this from *Campium linnaeanum*.

7. CAMPIUM LANCEOLATUM (Fée) Copeland, comb. nov. Plate 5, fig. 2.

Leptochilus lanceolatus FÉE, Acrost. (1845) 87, pl. 47.

Frondibus simplicibus, glabris; sterilibus lanceolatis utrinque acutis, basi decurrentibus, membranaceis, margine repandis, subundulatis; fertilibus longissimis, linearibus, attenuatis, longe petiolatis, petiolis helveolis.

[11] Ferns Brit. India and Ceylon (1892).

laevibus; rhizomate repente, fibrillis tomentosis, fusco-rufis; sporangiis late ovatis, annulo 14 articulato; sporis ovoideis, laevibus nudis.

Habitat in Indostan, Neilgherries (Perottet, 1838).—V. S. in herb. de Lessert.

Exsiccatum: Hügel, Asia, no. 1348, in herb. Vindob.

Dimensions: Frondes stériles, longueur, 60–65 centim.; le petiole égale la lame en dimension; largeur, 5–6 centim.

Frondes fertiles, longueur, 75 centim., le pétiole ayant 50 centim., largeur, 3–4 millim.—FÉE.

I have not seen a specimen positively referable to this species except from peninsular India, where it seems to be common. Specimens with this name, from Sikkim, Assam, etc., approach *Campium decurrens*, which also occurs there. Beddome ascribes to this species (as a variety of *Gymnopteris variabilis*) a wide range of forms, differing in shape, and particularly in the fructification, variously restricted, and even broken into distinct sori. I do not try to decide from the descriptions what these forms may be. So far as I can judge from the specimens examined, this species has been construed correctly as including *Leptochilus thwaitesianus* Fée.

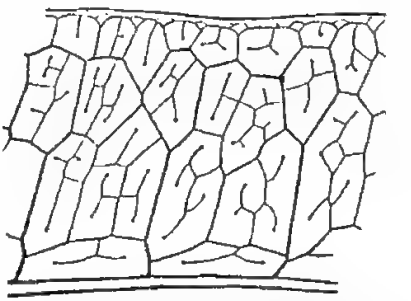

FIG. 6. *Campium lanceolatum* (Fée) Copeland, comb. nov.; peninsular India.

Key to the Oriental species of the section Heteroneuron.

Fronds pinnate or main veins conspicuous.....§ 2. *Heteroneuron.*

(For key to the African species, see p. 393.)

1. Sterile fronds simple and undivided.
   2. Free included veinlets many.
      3. Fertile frond narrowly linear.
         4. Stipe not articulate ..... 8. *C. decurrens.*
         4. Stipe jointed to rhizome..... 10. *C. laciniatum.*
      3. Fertile frond lanceolate ..... 11*a*. *A. zollingeri.*
      3. Fertile frond broad and short ..... 9. *C. ovatum.*
   2. Free included veinlets few or none.
      3. Fertile frond linear ..... 17. *C. foxworthyi.*
      3. Fertile frond broader.
         4. Frond thick and dark..... 11. *C. subsimplex.*
         4. Frond thin, light green ..... 15. *C. diversifolium.*
1. Fronds regularly pinnatifid with many near-pinnæ.
   2. Free included veins few or none ..... 27. *C. neglectum.*
   2. Free included veinlets in all areolæ..... 10. *C. laciniatum.*
1. Fronds trifid or paucipinnate, or dwarfed.
   2. Stipe stout, frond thick and dark..... 11. *C. subsimplex.*
   2. Frond not thick and dark.
      3. Fronds usually less than 15 cm tall.

4. Apex made up of coadunate pinnæ.
5. Areolæ of pinnæ all costal.
6. Pinnæ approximate ..... 28. *C. taylori.*
6. Frond lax ..... 30. *C. argutum.*
5. Areolæ more numerous ..... 29. *C. parvum.*
4. Apex not formed of fused pinnæ.
5. Terminal leaflet narrowly linear ..... 18. *C. tenuissimum.*
5. Apex not lashlike..... 19. *C. cuspidatum.*
3. Fronds of moderate size or large.
4. Not proliferous.
5. Pinnæ at most two pairs..... 15. *C. diversifolium.*
5. Pinnæ about four pairs ..... 16. *C. pseudoscalpturatum.*
6. Apical segment crenate-lobed ..... 32. *C. boivini.*
6. Apical leaflet serrulate ..... 42. *C. bradfordi.*
4. Normally proliferous.
5. Pinnæ coadunate above the base..... 26. *C. rivulare.*
5. Apex normally one leaflet.
6. Paleæ on stipe few, not dark..... 13. *C. heteroclitum.*
6. Stipe clothed with dark scales..... 14. *C. nigrum.*
1. Not dwarfs, pinnæ several, dark and coriaceous.... 11. *C. subsimplex.*
11*b*. *G. cadieri.*

1. Not dwarfs, pinnæ numerous, not dark and thick.
2. Apex made up of coadunate pinnæ.
3. Pinnæ crenate to shallowly lobed.
4. Pinnæ cuneate on both sides.
5. Lobes toothed or crenate..... 24. *C. palustre.*
5. Lobes entire ..... 25. *C. samoensis.*
4. Base of pinna broad.
5. Free pinnæ merging into lobes.
6. Pinnæ lanceolate, acute..... 21. *C. validum.*
6. Pinnæ broader, acuminate ..... 20. *C. quoyanum.*
5. Change from pinnæ to lobes abrupt.
6. Pinnæ broadest below middle..... 22. *C. subcordatum.*
6. Pinnæ broadest above middle..... 23. *C. interlineatum.*
3. Pinnæ cut over half-way to costa.
4. Areolæ all costal ..... 28. *C. taylori.*
4. Areolæ along costa and main veins..... 30. *C. argutum.*
4. Areolæ not all touching main veins.
5. Areolæ between sinus and costa not very broad.
20. *C. quoyanum.*
5. Areolæ between sinus and costa very broad.
31. *C. bipinnatifidum.*
3. Pinnæ hardly crenate ..... 33. *C. semicordatum.*
3. Pinnæ quite entire..... 32. *C. boivini.*
2. Apical leaflet not made by fusion.
3. Veinlets uniting in pairs, with an excurrent one where they meet, as in *Goniopteris.*
4. Pinnæ narrowly lanceolate ..... 45. *C. féeanum.*
4. Pinnæ broad.
5. Green, apex proliferous..... 44. *C. subcrenatum.*
5. Brownish, apex not proliferous..... 43. *C. molle.*

3. Venation more ample.
  4. Veins or entire frond reddish.
    5. Coriaceous and entire ..... 39. *C. costatum.*
    5. Herbaceous and toothed..... 37. *C. scalpturatum.*
  4. Green, usually light.
    5. Veinlets all free near margin.
      6. Margin crisped, not crenate..... 36. *C. crispatulum.*
      6. Margin crenate, not crisped.
        7. Sporangia remote from costa..... 38. *C. undulatum.*
        7. Sporangia covering the surface.... 35. *C. angustipinnum.*
    5. Veinlets uniting to near margin.
      6. Pinnæ over 20 cm long, narrow.....34. *C. lanceum.*
      6. Pinnæ 10 to 20 cm long, broad.
        7. Fertile fronds broad..... 40. *C. deltigerum.*
        7. Fertile fronds linear..... 41. *C. virens.*
      6. Pinnæ hardly 10 cm long.....33. *C. semicordatum.*

8. CAMPIUM DECURRENS (Blume) Copeland, comb. nov.

Leptochilus decurrens BLUME, Enum. Pl. Jav. (1828) 206.

L. frondibus simplicibus membranaceis glabris longe stipitatis, sterili cuneato-oblonga basi in stipitem decurrenti parallelo-venosa reticulata, fertili angusto-lineari elongata.

Obs. Priori (L. axillari) differt fronde sterili lato-oblonga, fertili longissima.

Crescit in humidis montanis Javae.—BLUME.

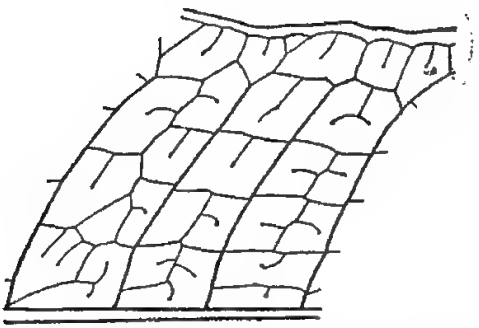

FIG. 7. *Campium decurrens* (Blume) Copeland, comb. nov.; Java, *Winckel 1335B.*

Sterile fronds 20 centimeters (or considerably more) long, including the stout stipe, along a part or all of which the lamina is decurrent; apex usually acuminate to caudate; color rather dark above, and brownish beneath; texture firm but not thick; main veins somewhat oblique in Malaya, almost horizontal in India, conspicuous nearly to the margin. An Assam specimen in the United States National Herbarium, collected by Gustav Mann, has a frond 65 centimeters long without the tip, and 12 centimeters wide.

The accepted range is Malaya to India.

In Malaya this is a decidedly uniform fern, for its genus. *Acrostichum variabile* Hooker, Sp. Fil. 5 (1864) 277, is a pure synonym, evidently provided because Blume's specific name was preoccupied in *Acrostichum*. The Himalayan ferns, on which Hooker's diagnosis was primarily based, seem to differ constantly from those in Malaya in having the main veins at very nearly a right angle to the costa, and more remote from one another, but this would ill justify specific separation. The status of Hooker's var. *β laciniatum*, of southern India and Ceylon, is decidedly different (see No. 13, *C. laciniatum*). Beddome [12] puts it under his var. *lanceolata*, where a laciniate or pinnate frond is even less to be looked for; but Beddome's usual skill in the recognition of species deserted him completely in this group, to which he also reduced, as a mere variety, as distinct a fern as *Leptochilus axillaris*. Because of his confusion, I abstain from trying to draw conclusions from his report of a form, apparently Burmese, with broad fertile fronds and polypodioid sori. In consideration of the existence of such forms, if indeed they are of this species, and of the very characteristic venation, it will not surprise me if future study shows that *Campium decurrens* originated in *Phymatodes*, or *Selliguea*, independently of *Leptochilus* and of the *Dendroglossa* group, and therefore requires generic separation. A vestigial articulation of the stipe is often evident, and on some young specimens it is clearly functional.

8a. CAMPIUM ZEYLANICUM (Fée) **Copeland, comb. nov.**

Leptochilus zeylanicus **FÉE**, 10th Mém. (1865) 8, pl. 31, fig. 1.

Frondibus sterilibus late lanceolatis, sessilibus, laminis decurrentibus, acutis; nervatione campyloneurorum, sed magis irregulari; fertilibus angustisimis, longissimis, petiolo nudo, extenso; sporangiis ovoideis, annulo lato 16–18 articulato; sporis brevibus, reniformibus.

Habitat in insula Zeylanica, (Thwaites, no. 1317.)

Filix repens, rhizomate tenui.

Cette espèce a quelque chose du porte du *L. decurrens*, mais elle en diffère essentiellement par la nature du tissu des frondes stériles, par les dimensions et par la manière dont est constitué le réseau nervillaire, a mailles extrêmement petites; c'est aussi là ce qui la sépare du *L. hilocarpus*, espèce à frondes plus courtes et plus manifestement sessiles.—FÉE.

Fée distinguishes this from *C. decurrens* by the texture, which he does not describe; by venation, as to which his figure and notes do not agree; and size, his figure showing a frond about 20 centimeters by 4—rather small, but well within the range of

[12] Ferns of British India and Ceylon 430.

C. decurrens. It is not strange that later authors combined the two. A plant in the United States National Herbarium, No. 815200, ex herbarium William Ferguson, seems to be altogether typical of this species, although one frond is 30 centimeters tall. The areolæ are not at all small, nor does Fée's figure so show them, but the venation is still distinct, in that the veins parallel to the costa, normally conspicuous in *C. decurrens*, are not developed in *C. zeylanicum*. The frond is more coriaceous, and very opaque, having to be cleared before strong transmitted light will reveal the venation. There is at least a vestigial articulation of stipe to rhizome. There is no such contraction of the frond some distance above the base, as is characteristic of *C. decurrens* in the Malay region. The paleæ are finely and regularly toothed.

FIG. 8. *Campium zeylanicum* (Fée) Copeland, comb. nov.

The Ceylon fern discussed on page 355, as a possible simple form of *C. laciniatum*, is longer-stalked, narrower, lighter in color, thinner, and with evident venation.

ACROSTICUM LISTERI Baker.

Acrostichum (§ *Gymnopteris*) *listeri* BAKER, Journ. Linn. Soc. Bot. 25 (1890) 361.

A. rhizomate late repente crassitie cygni pennæ, stipitibus sterilibus elongatis subnudis haud contiguis, frondibus lanceolatis membranaceis acutis basi attenuatis, venis primariis perspicuis parallelis, intermediis in areolas copiosas hexagonas anastomosantes venulis liberis inclusis productis, frondibus fertilibus linearibus stipitibus longioribus.

A well-marked new species, allied to the Himalayan, Ceylonese, and Malayan *A. variabile*, Hook. Stipes of the sterile frond 7–8 inches long. Sterile frond 9–12 in. long, 2 in. broad, narrowed gradually to the apex and more suddenly to the base. Fertile frond 4–5 in. long, under ½ in. broad at the middle, narrowed gradually to both ends.—BAKER.

Christmas Island (200 miles south of Java).

This is evidently large and long-stalked, and the implication is that the fertile frond is notably broad; otherwise, this seems to be closer to the *Campium decurrens* of Java than are many of the Indian forms which Baker treated as that species (under the name of *Acrostichum variabile*). I have seen no specimen.

9. CAMPIUM OVATUM Copeland, comb. nov. Plate 6.

Leptochilus ovatus COPELAND, Philip. Journ. Sci. § C 9 (1914) 229.

Fronde sterile lata, venarum ramis prope marginem praestantioribus; frondis fertilis stipite 35 cm alto, gracile, lamina anguste ovata, vix 6 cm longa, 2.5 cm lata; aliter L. decurrenti Bl. similis.

No. 155. "Scandent near base of small trees, in moist shade."—COPELAND.

The type specimen was collected by Cecil J. Brooks at Lebong Tandai, Benkoelen, Sumatra. There is an obvious possibility,

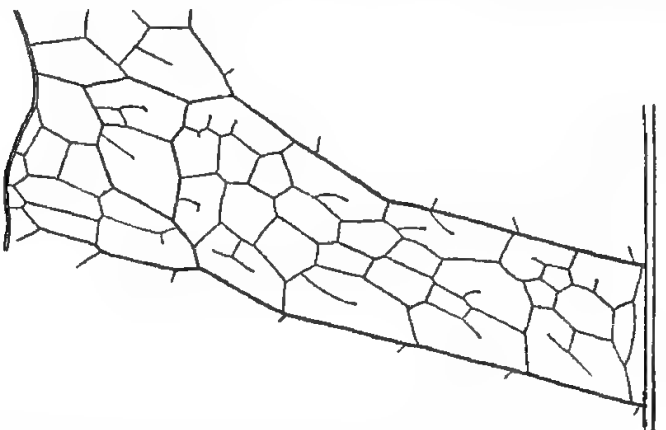

FIG. 9. *Campium ovatum* Copeland, comb. nov.; type. Frond simple.

emphasized by Mr. Brooks's note on the habit, that this is an independent offshoot of *Selliguea;* but I think it more likely that it is a real relative of the ferns with which it stands here.

10. CAMPIUM LACINIATUM Copeland, sp. nov. Plate 7.

Rhizomate repente, 2–3 mm crasso, nigro prope apicem paleis nigro-fuscis ca. 2 mm longis ovatis acutis suberoso-denticulatis basibus aut peltatis aut profunde cordatis cum lobis basalibus imbricatis vestito, alibi sparse paleato vel glabrescente; stipitibus seriatis, articulatis, gracilibus, stramineis vel fulvis, frondium sterilium 5–20 cm, fertilium 12–25 cm altis; fronde sterile deltoideo-ovata, 15–25 cm alta, 15–25 cm lata, acuta vel

acuminata, basi anguste et abrupte decurrente, glabra, membranacea, pinnatim laciniata, ala costae 1–10 mm lata, laciniis plerumque lanceolatis, remotis, late patentibus, acutis vel acuminatis, integris vel rarius frondium majorum infimis iterum laciniatis, venatione secundum dissectionem frondis irregulare, costulis rectis, venis ubi latior lamina subrectis, venulis ubique anastomosantibus cum liberis saepius furcatis apicibus globosis in areolis omnibus; fronde fertile 15–25 cm alta, deorsum pinnata, sursum ad alam angustissimam rhacheos fructiferam pinnatifida, ramis remotis, 3–6 utroque latere, usque ad 10 cm longis, 1 mm latis, infimis saepe furcatis.

Ceylon. Type in the Gray Herbarium, ex herbario William Ferguson. In same herbarium, *Thwaites* and *Beckett 215;* in the United States National Herbarium, No. 1277199, *Hancock 44.*

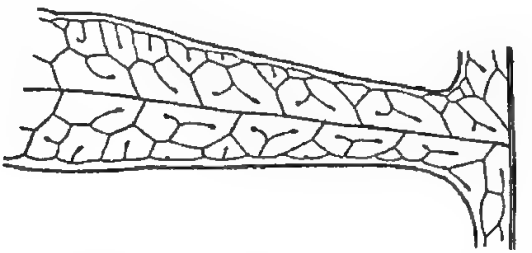

FIG. 10. *Campium laciniatum* Copeland, sp. nov.; type.

This is *Acrostichum decurrens* forma *fronde pinnatifida* Thwaites, Enum. Ceylon Plants, 381; *A. variabile* var. *laciniatum* Hooker, Spec. Fil. 5: 277. The affinity is to *Campium decurrens,* rather than to *C. lanceolatum,* as Beddome seemed to think.

However, the fern with entire fronds with which it may perhaps blend is not *Campium decurrens,* of which I have seen no Ceylon specimen. This fern, the subject of Plate 5, fig. 1, is represented in the Gray Herbarium by a specimen distributed from Kew as "*Acrost. lanceolatum* Hook. Peninsula Indiae Orientalis No. 3177. Herb. Wight." Contrasted with *Campium decurrens* the frond narrows uniformly from the widest part of the wing of the stipe, the veins are inconspicuous, the stipe is conspicuously jointed to the rhizome, and the paleæ are short and blackish. It is still less like *C. lanceolatum.* I leave it unnamed on the chance that it is a simple *C. laciniatum,* which I doubt its being. My more serious doubt is as to its being a true *Campium.*

11. CAMPIUM SUBSIMPLEX (Fée) Copeland, comb. nov. Plate 3.

Gymnopteris subsimplex FÉE, Acrost. (1845) 83, pl. 40, fig. 3.

Frondibus subsimplicibus, inaequaliter crenatis, glabris; sterilibus lanceolatis, basi subrepandis, nervillis secundariis flexuosis, nigrescentibus; fertilibus angustioribus acutis; sporangiis ovalibus, annulo 16 articulato, sporis episporio membranaceo,—siccitate lurida.

Habitat in Philippinis . . . Cuming no. 225.—FÉE.

Poecilopteris subrepanda Presl, Epim. Bot. (1851) 171, is absolutely synonymous with this, based on the same collection, and with similar description; Presl simply elected his specific name with the feeling, general in his time, that such publication as Smith's list of names of Cuming's plants should be accepted as establishing these names.

This is a common fern in the Philippines. It probably has a very much wider range, but this is uncertain because of confusion of names. *Dr. King's collector 8398,* from Perak, is this species. It is the most variable species in the genus. Its general distinctive characters are the stout, woody rhizome with large paleæ, stout stipes, and thick fronds, dark green above and olive green beneath, with strictly toothless margin, and the fertile frond or pinnæ never narrowly linear. The rhizome is 4 to 10 millimeters thick, and the brown or blackish scales up to 1 centimeter long on large specimens. The stipes are almost clustered, stout, dark, usually glabrescent, those of the sterile plant from quite short up to 30 centimeters long, winged upward if the frond is simple, those of the fertile fronds of the same plants the longer.

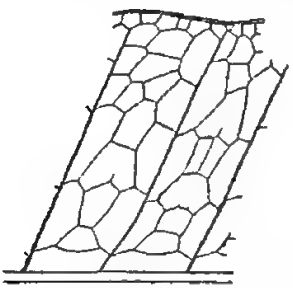

FIG. 11. *Campium subsimplex* (Fée) Copeland, comb. nov.; *Bolster 244.*

The sterile fronds are: 1, simple and sometimes very large, even up to 50 centimeters long and 9 centimeters wide, short-acuminate and long-decurrent, entire or slightly sinuate; 2, pinnate with very few pinnæ, and the upper part like a simple frond; or 3, pinnate with half a dozen pairs of pinnæ and the apical leaflet like the others. The last form is the rarest, but can be construed as representing the species in its fullest development. The type, as described, had a simple sterile frond. The simple and the paucipinnate forms are connected by fronds forked near the base on one or both sides. A rare transition form has several lobelike adnate decurrent pinnæ below the

large, simple body of the frond; another has one or two dwarfed pinnæ between a pair of large basal ones and the still larger apical leaflet. The fertile fronds or pinnæ are smaller, but never very narrow. The costa is prominent, and the main veins are likely to be sufficiently developed to break the mass of sporangia into groups.

A bud near the apex is not as constant a feature as it is in *Campium heteroclitum* and *C. quoyanum*, but is still common. It is more likely than in other species, while still connected with the parent plant, to grow into a daughter plant of considerable size, as shown in Plate 8. Bearing such daughter plants, it is quite surely *Leptochilus stolonifer* Christ.

The venation varies with the size and the dissection of the frond, but always retains the essential character of its group, betraying a certain affinity to *Campium heteroclitum*, the species that may be regarded as providing the pattern. If the lamina, of frond or pinna, is very ample, the veins are usually far apart, and two four rows of irregular areolæ may separate the regular ones bordering the main veins. If the pinnæ are narrower and the veins closer together, only one such row may be found. A few free included veinlets can usually be detected, but not many nor with any regularity; they are simply veinlets that would normally reach a connection with others, but fail to do so.

Probably identical with this is the following:

11a. ACROSTICHUM ZOLLINGERI Kunze.

Acrostichum zollingeri KUNZE, Bot. Zeit. 4 (1846) 419.

Fronde membranacea, glabra, lanceolata, apice attenuata, basi decurrente, margine repandula, costa subtus convexa, lurida venis primariis patentibus, prominulis, secundariis reticulatis, immersis, fronde sterili late lanceolata, in stipitem brevissimum longe decurrente; fertili anguste lanceolata basi attenuata, in stipitem mediocrem brevius decurrente; soris nec costam nec venas primarias obtengentibus, utriusque stipite fusco-paleacea, basi adscendente; rhizomate horizontali (brevi?) fusco-paleaceo, nigro-radicoso.

Frons sterilis illi *Leptochili decurrentis* Bl. (Fée Acrost. t. 48, f. 2) similis; sed fertilis diversissima, sterili subconformis, quamquam angustior. Frons circiter pedalis, lamina sterilis 9–10″ longa, 1″ 10‴ lata; fertilis 6½—7″ lango, 8‴ lata—KUNZE.

Java, *Zollinger 1293*.

The statement of van Alderwerelt,[13] who does not appear to have seen this fern, that it has copious free veinlets, may have

[13] Malayan Ferns 743.

been due to confusion with *Hemionitis zollingeri* Kurz, which is a *Hemigramma*, but also in its time endowed with a name in *Leptochilus*.

11b. GYMNOPTERIS (LEPTOCHILUS) CADIERI Christ.

Gymnopteris (*Leptochilus*) *cadieri* CHRIST, Journ. de Bot. 19 (1905) 126.

Voisin de *G. subrepanda* J. Sm. Bot. Journ. 3 403, mais plus mince, tissu et nervation différents.

Rhizomate repente crasso, cum basi stipitum squamis atro-brunneis subulatis rigidis vestito, foliis subfasciculatis, sipite 25 cent. longo lucido-rufo sulcato pennae corvinae crassitie, fronde deltoidea 30 cent. longa 25 cent. lata, pinnata, pinna terminali pinnisque utroque latere recheos tribus similibus fere sessilibus nec adnatis, confertis, 16 cent. longis 4 cent. latis basi ovato-rotundatis oblongis acuminatis, apice interdum producto gemmulamque minimam ferente, faciebus glabris, margine integro sed undulato-repandulo, textura coriacea, colore atrovirente, costa tenui manifesta, nervis tenuibus patentibus rectis usque ad marginem protensis 6 mill. distantibus, nervulis 5 inter costam et marginem, convexo-arcuatis, areolam duosque nervulos liberos clavatos areolam coronantes includentibus.

Lamina fertili 15 cent. longa longius stipitata, stipite 40 cent. longo 11 pinnis alternis remotis oblongis 5 cent. longis 2/3 cent. latis obtusis omnino sporangiis brunneis tectis.

Hab. (Annam) Thanh Than . . ., grandes forêts, bords des torrents. Fevr. 1905. Cadière no. 146.—CHRIST.

I do not know this fern, and insert it at this point entirely on the strength of Christ's statement as to its affinity; however, it must be noted that the presence of clavate free included veinlets throws doubt on this statement. Such veinlets are a characteristic of *Hemigramma* and are not found in any sure species of *Campium* with compound fronds.

12. CAMPIUM HYDROPHYLLUM (Copeland) Copeland, comb. nov. Plate 9.

Leptochilus hydrophyllus COPELAND, Philip. Journ. Sci. 1 Suppl. (1906) 146.

Rhizomate brevi-repente, 1–1.5 mm. crasso, apicem versus paleis fuscis, angustis, 1 mm. longis vestito; stipite frondis sterilis circa 1 cm. alto, subsquamoso, frondis fertilis 4–7 cm. alto; fronde sterile plerumque 10 cm. alta, 10 mm. lata, integra, rarius 20 cm. alta et undulata, acuta, basi subacuta, viva carnosula, sicca papyracea, glaberrima; venis immersis, inconspicuis, marginem vix attingentibus, venulis more L. cuspidati anastomosantibus, liberis inclusis paucis; fronde fertile lineare, ca. 7 cm. alta, 3 mm. lata, obtusa, in stipitem sensim angustata.

FIG. 12. *Campium hydrophyllum* Copeland, comb. nov.; type. Frond simple.

MINDANAO, Zamboanga, San Ramon, *Copeland* 1565. Ad saxa humida.—COPELAND.

The color is dark olivaceous-green. The color, texture, venation, and margin mark this as a near relative of *Campium subsimplex,* and I believe it is more reasonable to regard it as evolved by arrested development from that species than as a link between *C. subsimplex* and the *Dendroglossa* group, to no species of which it shows an equally clear affinity. In common with *C. subsimplex,* and various *Dendroglossa* species, it has dark, opaque fronds. Free included veinlets are not rare in broader fronds than the one drawn.

13. CAMPIUM HETEROCLITUM (Presl) Copeland, comb. nov.

Acrostichum heteroclitum PRESL, Rel. Haenk. 1 (1825) 15, pl. 2, fig. 2.

A. frondibus ternatis, foliolis lateralibus oblongo-lanceolatis acuminatis dentatis oppositis, intermedio lanceolato linearive, grosse dentato vel integerrimo, acuminato, fructiferae foliolis lineari-lanceolatis.—PRESL.

Presl followed his formal diagnosis with a list of five various forms, differing in the number of leaflets and in the elongation of the apex and production of bulbils or young plants. His illustration shows the commonest form, with one pair of lateral pinnæ, and the terminal leaflet long-attenuate and rooting.

Acrostichum flagelliferum Wallich: Hooker and Greville, Ic. Fil. (1829) pl. 23.

Fronde pinnata, pinnis paucis remotis lanceolatis (magisve minusve latis) breviter petiolatis, terminali longissima flagelliformi.

Hab. In India Orientali. *Rheede. Wallich.*—HOOKER AND GREVILLE.

A very variable fern. It is common at low altitudes, usually found in abundance, and a considerable range of forms can usually be collected, in the Philippines, wherever it is found. Simple fronds on adult plants are not uncommon; they are cuneate, broad above the base, with the upper part drawn out into the characteristic tail. Fronds cleft on one or both sides show the transition to the typical form. There may be more than one pair of pinnæ, but never many. These are stalked (except on transition forms from simple fronds), narrowed to the base, ovate, entire or undulate or obscurely and irregularly toothed, and acuminate or caudate; but proliferous pinnæ are very unusual. The terminal pinna may be broad near its base, like a simple frond; or it may be narrow throughout its length. It is not rare for its whiplashlike upper part, growing on and on until it touches the ground, to reach a length of well over half a meter.

The most characteristic feature of the species is this lash, which gave it the name by which it was long known, *Acrostichum flagelliferum.* The rhizome is wide-creeping, slender, consider-

ing the size of the fronds—3 to 4 millimeters in diameter, in adult plants—not very densely clothed with small, dark, scurfy scales. The stipes are seriate, not clustered at all, 15 to 30 centimeters long on sterile fronds, those of fertile fronds of the same plant somewhat longer, stramineous, sparsely scaly. The sterile fronds are thin, clearly green, neither blackish nor olive, paler on the nether side. The costa and conspicuous main veins are very pale. The fertile pinnæ are of the same general form as the sterile, but smaller and somewhat narrower, never narrowly linear.

An unusual variant, found, however, well throughout the range of the species, has the terminal leaflet like the lateral ones in shape, but usually larger. This form is *Cyrtogonium acuminatum* Brackenridge. Compensating for the comparative suppresion of terminal proliferation, the lateral pinnæ are likely to be notably caudate, with buds which are usually dormant.

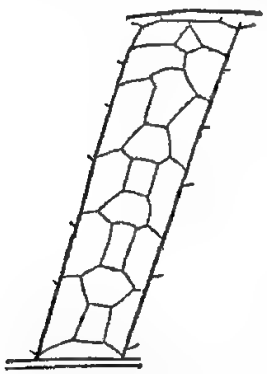

FIG. 13. *Campium heterodictum* (Presl) Copeland, comb. nov.; *Cuming 5.*

The venation is ill figured by Presl in the Reliquiae Haenkeanae, and not too well in the Tentamen. Beside the single regular row of areolæ along each side of the costa, there is a less regular one on each side of each main vein. Typically, the middle of the space between each pair of veins is occupied by one more row of areolæ, twice as numerous. It is in this middle row that irregularity occurs, the commonest deviation being the presence of two or more irregular rows. Free included veinlets are wanting, except as an occasional veinlet fails to reach the one toward which it starts.

Range: Malaya to India, China, and Papua. From the Philippines to the Himalayas, there is a gradual loss of regularity in the venation.

Dealing with a group of plants like this, which, within limits, is exceedingly unstable, it is easy for the student to be baffled, and to conclude that the variation has no clear limits. In his treatment of this species, Christ[14] seems to me to have done this. Leaving out of account his *linnaeanus*, for the reduction of which a wrong determination must have been responsible, I

[14] Philip. Journ. Sci. § C 2 (1907) 159.

believe that two of the other three varieties he describes are established, if local, species. The transition to these, as I see it, is no more clear, and no more filled by known intermediate forms, than is that to *Campium diversifolium* or to several other species. Certainly, all are related.

CAMPIUM HETEROCLITUM var. EURYBASIS (Christ) Copeland, comb. nov.

Leptochilus heteroclitus var. *eurybasis* CHRIST, Philip. Journ. Sci. § C 2 (1907) 159.

This variety is based on *M. S. Clemens 552*, from Camp Keithley, Mindanao. Its characteristics are smaller stature and deeply cut lateral pinnæ which are short and very wide at the base, with toothed margins. As described, it looks like a distinct species, almost as near to *Campium quoyanum* as to *C. heteroclitum*. Very ample material, collected by Mrs. Clemens, partly bearing the stated number and partly without number, shows that it intergrades almost completely with the species to which Christ assigned it. Many fronds have the terminal leaflet drawn out, and a few have started to develop buds; and a few have the venation almost as regular as is here pictured for *C. heteroclitum*. Such forms are atypical in being somewhat cut, and in bearing marginal teeth, some of which are quite like the cusps of the *quoyanum* group of species. Such plants are found elsewhere in Mindanao, and more rarely throughout the Philippines, and are likely to be sent in as single specimens, without collector's number. *Weber 1553* from Cagayan Province, in the extreme northern part of Luzon, is typical *C. heteroclitum*, except that it bears a single "juvenile" frond, only 7 centimeters long, which conforms perfectly to the varietal diagnosis.

This variety is of particular interest because the respects in which it deviates from the type lead, on one hand, toward the dwarf species, *Campium cuspidatum* and *C. tenuissimum*, and on the other toward *C. quoyanum* and its numerous relatives. As was partly known to Christ, there are in the Philippines many undescribed and remarkably various dwarfs, locally more or less established, but evidently enough descended from *C. heteroclitum*.

14. CAMPIUM NIGRUM Copeland, sp. nov. Plate 10.

C. gregis C. heterocliti, quo stipite valido paleis angustis atrofuscis usque ad 7 mm longis persistentibus ornato, pinnis viridinigris opacis differt; rhizomate 6 mm crasso; stipitibus haud remotis, 20 cm altis, fulvis; frondis sterilis pinnis utroque latere 2, ca. 12 cm longis, 4–5 cm latis, acuminatis, basibus latis sub-

sessilibus, margine irregulariter crenulato-denticulatis, tenuiter papyraceis sed opacis; venis infra marginem sursumcurvatis et dissipatis, venulis more C. heterocliti anastomosantibus. Fronde fertile non visa.

Ponape, Caroline Islands, *T. Karigone 69*, 1925. Type in the herbarium of the University of California, No. 287252.

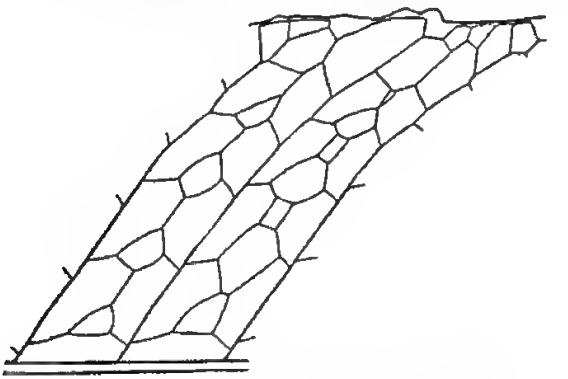

FIG. 14. *Campium nigrum* Copeland, sp. nov.; type.

Certainly very near to *Campium heteroclitum;* but the combination of frond color and opacity and of the striking scaliness of the dark, stout stipes marks it off clearly enough. Except in venation, it is more like the Indian (*flagelliferum*) form than like the common Philippine *C. heteroclitum*.

15. CAMPIUM DIVERSIFOLIUM (Blume) Copeland, comb. nov.

Acrostichum diversifolium BLUME, Enum. Pl. Jav. (1828) 193; Fl. Jav. 2 (1828) 36, pl. 12.

A. frondibus longe stipitatis integerrimis membranaceis glabris parallelovenosis, sterilibus simplicibus, oblongo-lanceolatis acuminatis, fertilibus ternatis, foliolis lateralibus minoribus obtusis, terminali elongata utrinque acuminata, stipite rachique angulatis glabriusculis.

Crescit in montibus Javae ad ripas fluviorum.—BLUME.

Found throughout Malaya. The type locality is more definitely fixed in Flora Javae as the foot of Mount Burangrang. The type specimen should be in the herbarium of the University of Leyden.

The sterile frond may be simple, as described, and 50 centimeters or more in length; or it may be cleft on one or both sides near the base; or it may have on each side one or two large pinnæ, and a larger terminal leaflet. I have received simple fronds of this, determined as *Leptochilus decurrens*, to which it really bears little resemblance. Its affinity, as Blume recognized, is to *Campium heteroclitum*. On larger fronds

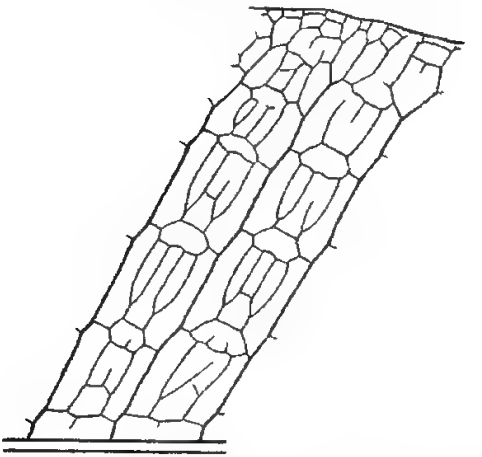

FIG. 15. *Campium diversifolium* (Blume) Copeland, comb. nov.; Java, *Palmer and Bryant 555*.

than the subject of my drawing, the veins are wider-spaced, and the reticulation of the veinlets is less uniform. Specimens from Mindanao (*Copeland 1543*) and from Alabat Island (*Merrill 10469*) are quite intermediate between *C. diversifolium* and *C. heteroclitum*.

16. CAMPIUM PSEUDOSCALPTURATUM Copeland, sp. nov. Plate 11.

Rhizomate repente, fere 1 cm crasso, paleis minutis fuscis vestito; stipitibus, frondis sterilis 30 cm, fertilis 35 cm altis, apud basin paleaceis, sordide stramineis; fronde sterile fere 40 cm alta, ovata, pinnata, pinnis alternantibus, utroque latere ca. 4, inferioribus stipitulatis, lneari-oblongis, maximis medialibus, 15–20 cm longis, 3–4 cm latis, acuminatis, basibus cuneatis, late et oblique inciso-crenatis, herbeceis, laete viridibus, costis stramineis venisque inferne prominentibus, venulis more C. heterocliti anastomosantibus, pinna apicale aliis conforme vel paullo latiore; fronde fertile minore, pinnis 6 cm longis, 8 mm latis.

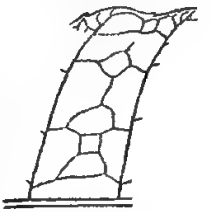

FIG. 16. *Campium pseudoscalpturatum* Copeland, sp. nov.; type.

CAMIGUIN DE MISAMIS, *Bur. Sci. 14816 Ramos*, 1912.

Except that it is somewhat more evidently crenate and that the terminal pinna is not contracted, this has a remarkable super-

ficial resemblance to Fée's plate of *Heteroneuron scalpturatum.* The venation, however, is of the plan of *Campium heteroclitum,* modified as the narrower pinnæ reduce the number of areolæ and in being more lax. The venation, margin, texture, and color of axes and lamina, all mark it as a near relative of *C. heteroclitum.* It is different in the stout rhizome, more numerous pinnæ of very distinct shape, and terminal pinna not lashlike; the last feature is likely to prove not constant, but the others may be presumed to be so.

17. CAMPIUM FOXWORTHYI Copeland, sp. nov. Plate 12.

Rhizomate repente, gracile, 1–2 mm crasso, paleis castaneis, linearibus, 1.5–2 mm longis vestito, glabrescente; stipitibus seriatis, gracilibus, viridulis, 5–8 cm longis, praecipue deorsum paleis paucis deciduis vestitis, frondium fertilium paullo longioribus; fronde sterile lanceolata, utrinque angustata, acuminata non flagellifera, interdum prolifera, integra vel superne obscure crenato-denticulata, herbacea, glabra, viride; venis primariis conspicuis, inter eas areolis triseriatis, venulis inclusis normaliter nullis; fronde fertile parva, 2–3 cm longa, lineari-lanceolata, aut integra aut ad basin utrinque pinna vel lobo minuto rotundato praedita.

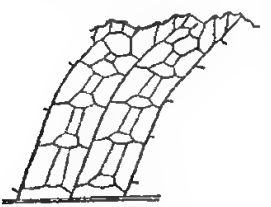

FIG. 17. *Campium foxworthyi* Copeland, sp. nov.; type.

LUZON, Rizal Province, *Bur. Sci. 68 Foxworthy,* 1906. Type in my herbarium.

From this collection number, Christ[15] described *Leptochilus heteroclitus* var. *foxworthyi,* but, at least as to the sterile frond, his description is not of the plant I have. A confusion of specimens or labels must be suspected; for it is not conceivable that Christ regarded this plant, with simple fronds, as "almost exactly intermediate between the type [*heteroclitus*] and the variety *inconstans.*"

18. CAMPIUM TENUISSIMUM Copeland, sp. nov. Plate 13.

Rhizomate repente, gracile, paleis castaneis 2–3 mm longis vestito; stipitibus brevibus, validis, stramineis, paleis paucis ornatis, frondium sterilium 2–3 cm, fertilium 3–4 cm altis; fronde sterile pinnata, pinnis utroque 1, rarius 2, stipitulatis, oblongis, 1–2 cm longis, obtusis, basi abrupte et oblique cuneatis, interdum basiscopice lobo uno praeditis, obscure denticulatis, herbaceis, venis magnitudinen laminae secundum paucis et irre-

[15] Philip. Journ. Sci. § C 2 (1907) 160.

gularibus, pinna terminale valde elongata, ca. 20 cm longa, 3–4 mm lata, infra apicem prolifera; fronde fertile conforme sed parva, 5–10 cm longa, pinnis lateralibus orbiculari-oblongis, terminale anguste lineare, oblique dense fructifera.

FIG. 18. *Campium tenuissimum* Copeland, sp. nov.; type.

LUZON, Laguna Province, Los Baños, *Copeland s. n.*, 1906. Type in my herbarium.

While very probably evolved by reduction from a larger species, this does not appear to me, in spite of the conspicuous proliferous flagellum, to be too closely related to *Campium heteroclitum* to justify its description as a distinct species.

19. CAMPIUM CUSPIDATUM (Presl) Copeland, comb. nov. Plate 14.

Nephrodium (?) *cuspidatum* PRESL, Rel. Haenk. 1 (1825) 31.
Heterogonium cuspidatum PRESL, Epim. Bot. (1851) 169. Not *Leptochilus cuspidatus* C. Christensen as to other synonyms.

N. frondibus lineari-lanceolatis glabris pinnatis, pinnis oppositis subsessilibus lanceolatis obtusis cuspidato-serratis membranaceis, terminali longissima lineari-lanceolata subradicante.

Hab. in insula Sorzogon. [Sorsogon Province, Luzon.]

Caudex repens teres glaber, radicibus longis flexuosis fibrillosis. Stipes pollicaris filiformis glaber, supra canaliculatus. Frons 3–5-pollicaris glaberrima membranacea pinnata. Pinnae semipollicares brevioresve sesquilineam latae, oppositae aut subopposítae, lanceolatae obtusae serratae, serraturis cuspidatis, basi in petiolum brevem attenuatae, terminali bitripollicari lineari serrata, basi lanceolata in petiolum attenuata s. cuneata, apice subinde radicans . . .—PRESL.

The clue to what *Nephrodium cuspidatum* really was, is given in the Epimeliae, where Presl identified it with the smaller and less-divided plants distributed under *Cuming 161*, the subject of the accompanying plate, distinguishing the more ample and more cut specimens as *Heterogonium argutum* Fée. My specimen of this number came with three names: *Cyrtogonium sinuosum* J. Sm. (status juvenalis), which is this form; *Heterogonium argutum* Fée; and *Acrostichum quoyanum* Gaudich., Hook.—the last two should not have been applied to this plant. It is well known that some of Cuming's fern collections from different places in the Philippines were combined under single numbers after they reached England, but before their distribution, with the result that it is not at all unusual for one number to apply to two or more species.

This is a small fern, usually not more than 10 centimeters in total height, with plural pinnæ, usually connected by a wing,

clearly evolved by reduction or arrested development of *Campium heteroclitum*. Depending upon the size of the pinnæ, the veins may be free, as in the accompanying drawing, or they may form a few areolæ.

With this species, I think it proper to combine *Gymnopteris inconstans* Copeland, Perkins' Fragmenta (1905) 178, a form collected many times along Lamao River, near Manila, which differs only in the constantly more entire margin. Christ recognized the affinity of this to *Campium heteroclitum*. The error, which has been prevalent in the identification of *C. cuspidatum* and in not assigning it to the same group, probably goes back to the original confusion of two species in Cuming's collection.

FIG. 19. *Campium cuspidatum* (Presl) Copeland, comb. nov.: *a*, from *Cuming 161*; *b*, from cotype of *Gymnopteris inconstans* Copeland.

20. CAMPIUM QUOYANUM (Gaudichaud) Copeland, comb. nov.

Acrostichum qvoyanum GAUDICHAUD, Bot. Freycinet's Voyage (1827) 306, pl. 3.

A. frondibus sparsis (?); sterilibus pinnatis, superioribus confluentibus; pinnis alternis, oblongo-lanceolatis, acuminatis, pinnatifidis; lacinis subfalcatis, obtusiusculis, duplicato-serratis, subciliatis; fertilibus pinnatis, pinnis petiolatis, lineari-lanceolatis, undulato-crenatis, superioribus subconfluentibus.

In insulis Moluccis (Pisang, Rawak, Vagiou, etc.).—GAUDICHAUD.

With the recognition of *cuspidatum* as the specific name of a member of another group of species, *quoyanum* becomes the valid specific name of the far commoner fern called *Leptochilus cuspidatus* by Christensen, and in the previous literature most commonly called *Acrostichum repandum* Blume. The dates of publication, given as 1827 and 1828, are so close together that Blume might well have been ignorant of Gaudichaud's species. Blume [16] described in succession, on the same page, *Acrostichum proliferum* from sterile plants and *A. repandum* from fertile, but in another publication [17] he recognized them as the same plant, and figured both fronds. His figure represents a fern less deeply cut and less sharply toothed than typical *Campium quoyanum*, and this is true of all Javan specimens in my hands, but these differences mark it as an established form, rather than make it worth while to try to recognize it as a species. This is a common fern in the Philippines, where the majority of

[16] Enumeration 104. [17] Flora Javae 39, pls. 14 and 15.

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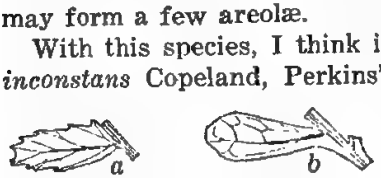

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[16] Enumeration 104. [17] Flora Javae 39, pls. 14 and 15.

specimens are closer to typical *C. quoyanum* than to the Javan form.

With some relatives, this forms a natural group, distinguished from the other species with copiously pinnate fronds by the gradual reduction of the pinnæ, toward the apex, the apical part of the frond, made by the "coalescence" of the upper pinnæ, being pinnatifid at its base, then lobed, and more or less entire near the tip. Proliferation is common in this group, as in that of *Campium heteroclitum*, but not usually among the species that have the terminal leaflet like the lateral ones. The rhizome is typically stouter and more woody than that of *C. heteroclitum*, and evidently of slower growth in length, for the stipes are almost clustered. Associated with this difference is the fact that *C. heteroclitum* is (rarely) found on tree trunks, and not rarely on large bowlders, while *Campium quoyanum* is quite strictly terrestrial.

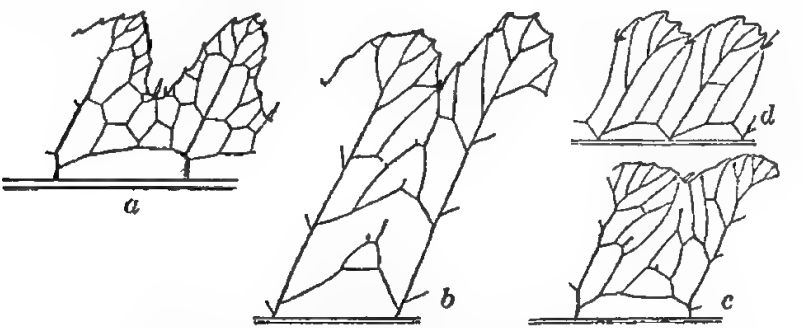


FIG. 20. *Campium quoyanum* (Gaudichaud) Copeland, comb. nov.; *a*, Mindanao, *Elmer 13458*; *b*, *Acrostichum repandum* Blume, Java, *Monsset 140*; *c*, *Campium quoyanum*, China, United States National Herbarium, No. 232248; *d*, near *Campium quoyanum*, Todaya, Mindanao, *Copeland s. n.*

Chrysodium bipinnatifidum Kuhn in the Seychelles represents this group in the West, as *Campium rivalare* and *C. palustre* do in the extreme East, and *Leptochilus taylori* (Bailey) C. Christensen in Australia. Between these geographical extremes, *C. quoyanum* seems to occupy the entire area. Toward the north it reaches southern China and Formosa and is reported from the Riu Kiu Islands. I cannot distinguish *Chrysodium naumanni* Kuhn, described from New Hanover, sufficiently to care to transfer the name. I have what seems to be this, from Papua, collected by C. King, and from Kaiser-Wilhelms Land, collected by Schlechter.

The sterile fronds of *C. quoyanum* are 30 to 50 centimeters long, on stipes 20 to 30 centimeters long. The stalked pinnæ,

half a dozen to a dozen or more pairs, are 8 to 15 centimeters long, 15 to 30 millimeters wide, acuminate, truncate at the base but usually less abruptly on the lower side; the margin is cut one-fourth to one-half of the way to the costa, forming toothed lobes, with or without bristles in the sinuses; if narrow, the lobes tend to be falcate; the lamina is thin, clear green, and glabrous, but the rachis is persistently slightly scaly. The fertile frond is similar in length, but the pinnæ are shorter, much narrower, and commonly sinuate instead of lobed. Rosenstock's variety *marginatum* [18] has unusually broad fertile pinnæ with the sporangia restricted to a marginal band. If the species were distinct, this should be referred to *C. naumanni*.

A rare Philippine form with deeply and permanently red sporangia is represented by *Cuming 294* (*Cyrtogonium laciniatum* J. Smith), from Leyte, and by *Elmer 13468* in part, from Mindanao.

Within the range of *Campium quoyanum*, it seems expedient to recognize as distinct the northern Luzon form to be described next. I have also a single plant from Todaya, Mindanao, altitude 800 meters, with sterile frond of the same general form as *Acrostichum repandum*, short, entire fertile pinnæ, the venation shown herewith, and some minor differences. It is probably a distinct species, but may await description until found again.

HETERONEURON SINUOSUM Fée.

Heteroneuron sinuosum FÉE, Acrost. (1845) 95, pl. 55, fig. 2.

Frondibus sterilibus pinnatis, rhachi squamis raris ferente, frondulis anguste lanceolatis, suboppositis alternisque, basilaribus petiolatis, ultimis sessilibus, repando-sinuatis, sinubus nervilla brevi instructis, apice acuminatis, basi acutis, terminali longiori, in acumine elongato desinente, petiolo longo, anguste canaliculato.

Habitat in Philippinis. Cuming nos. 105 et 161 in herb. Vindob. non alibi.

Dimensions: La longueur totale des frondes fertiles, les seules que nous connaissions, atteint 45 centim., mesure prise à la base de la frondule terminale; celle-ci a près de 14 centim., sur 15–18 millim. de large; le pétiole égale la lame en longueur. Nous avons sous les yeux des spécimens un peu plus petits, avec des sinus moins marqués.—FÉE.

Very evidently, it was not the fertile, but the sterile fronds that alone were known by Fée. *Cuming 105* in the United States National Herbarium is this plant, but *Cuming 161* in that herbarium is Fée's *Heteroneuron argutum*. I have collected this fern (*H. sinuosum*), young and sterile, near Pagsanjan,

[18] Fedde's Repert. 9 (1911) 426.

Laguna Province, Luzon, and with it another, adult but having lost its fertile pinnæ, intermediate between this and *Campium quoyanum*. The young plant is decidedly reddish, as is less conspicuously true of the Cuming specimen, but not of my adult plant. An approach to this fern is presented by some of the very aberrant plants referred to *C. heteroclitum*, but the affinity to *C. quoyanum* is the more evident. This looks like a distinct species, but I am not giving it a name in *Campium* until fertile specimens may establish its status better.

FIG. 21. *Heteroneuron sinuosum* Fée; cotype.

11. CAMPIUM VALIDUM Copeland, sp. nov. Plate 15.

Rhizomate lignoso, 1 cm crasso, paleis parvis fuscis obtecto; stipitibus, frondis sterilis 30 cm, fertilis 45 cm altis, validis, brunneis, pedibus paleaceis, alibi nudis; fronde sterile 40 cm alta, ovato-lanceolata, rhachi brunnea; pinnis utroque latere 15, inferioribus brevipedicellatis, fere 10 cm longis, 2 cm latis, acutis, basi truncatis subobliquis, inciso-lobatis, sursum gradatim minoribus et obtusis, segmento apicale frondis e pinnis coadunatis composito parvo, ca. 8 cm longo, acuminato, prolifero; venis more *C. quoyani* anastomosantibus; frondis fertilis pinnis paucis, aequalibus, fere 10 cm longis, 15–20 mm latis, profundius lobatis.

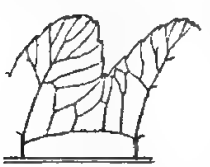


FIG. 22. *Campium validum* Copeland, sp. nov.; type.

LUZON, Cagayan Province, *Bur. Sci. 13807 Ramos*, 1912.

One of the group of *Campium quoyanum*. The fertile frond is remarkable enough to be suspected of being a monstrosity. The sterile frond differs from that of common *C. quoyanum*, in its naked axes, more numerous and blunter pinnæ, regularly decreasing in size toward the apex, and in the small and narrow apical segment.

12. CAMPIUM SUBCORDATUM Copeland, sp. nov. Plate 16.

C. gregis C. quoyani pinnis basi plus minus cordatis; rhizomate repente, 1 cm crasso, apice paleis nigro-castaneis late lanceolatis integris acuminatis 2–3 mm longis vestito; stipite frondis sterilis usque ad 40 cm alto, fusco-fulvo, sordide squamuloso, sursum rhachique superne bisulcatis; fronde sterile (exempl. visorum) 35–40 cm longa, 20–30 cm lata; pinnis utroque latere ca. 7, medialibus 15 cm longis, 3.5 cm latis, plerisque falcato-caudatis, subsessilibus, basi subcordatis vel solummodo

truncatis, leviter crenato-lobatis lobis crenulatis sinubus saepe setiferis, tenuiter papyraceis, costis fulvis inferne praestantibus; areolis inter venas primarias pluriseriatis vel irregularibus, areola infima quae nec costam nec venas attingit venulam unam simplicem excurrentem includente, liberis inclusis alibi, ob imperfectionem reticulationis, haud carentibus; pinnis infimis oppositis paullo latioribus basiscopice rotundatis; foliola terminale majore, profundius falcato-lobatis, sub apice prolifera; fronde fertile angustiore, 30–40 cm longa vix 10 cm lata; pinnis utroque latere 7–10, remotis, ca. 6 cm longis, vix 1 cm latis, obtusis, basi truncatis, crenato-undulatis.

Hainan, southern slope of Five Finger Mountain, *McClure, Canton Chr. Coll. 9436.* Type in the herbarium of the California Academy of Science, No. 91888. Also in the same herbarium, No. 9346.

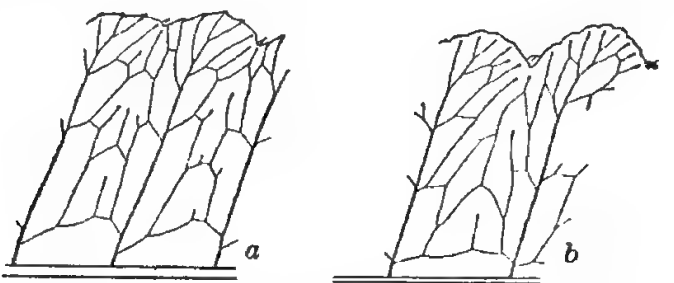


FIG. 23. *Campium subcordatum* Copeland, sp. nov.; *a* type; *b*, cotype.

Sterile specimens from Hong Kong (*Oldham*) and Chekiang (*H. H. Hu 156*, 1920) probably are this species, but are not mature or complete enough for positive determination. Fu Kien specimens, *Norton 1058* and *1059*, are likewise sterile, but quite positively belong here. Specimens from Hainan, *Eryl Smith 1641*, and Hong Kong, *Wright s. n.*, are likewise referred here, though the fertile pinnæ are smaller than those described, and the lateral sterile pinnæ are toothed but not lobed.

23. CAMPIUM INTERLINEATUM Copeland, sp. nov. Plate 17.

Rhizomate lignoso, 6 mm crasso; stipitibus approximatis, frondis sterilis 35 cm, fertilis, 45 cm altis, rhachibusque brunneis, sordide furfuraceis sursum glabrescentibus; fronde sterile 50 cm longa, 25 cm lata, pinnata; pinnis utroque latere ca. 8, brevipedicellatis, majoribus 15 cm longis, 35 mm latis, falcato-caudatis, basi truncatis vel superioribus latere acroscopico cuneatis caudam versus falcato-crenatis rhachin versus undulatis,

papyraceis, rubido-tinctis, segmento treminale latiore subinciso; venis usque in lobos marginis protensis; venulis more C. quoyani anastomosantibus, sed ob magnitudinem et texturam firmiorem frondis reticulationem ampliorem efficientibus, cum liberis inclusis haud paucis venam spuriam inter veras simulantibus, fronde fertile conforme, pinnis ca. 6 cm longis, 8 mm latis, integris.

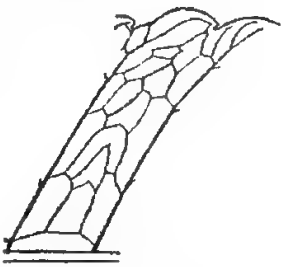


FIG. 24. *Campium interlineatum* Copeland, sp. nov.; type.

Borneo, Sarawak, Bungo Range, *C. J. Brooks 12*, 1909.

This has the frond form of a large *Acrostichum repandum*, but the texture and the venation are distinctive. The reddish caste suggests *C. scalpturatum*, but the venation is very different.

24. CAMPIUM PALUSTRE (Brackenridge) Copeland, comb. nov. Plate 18.

Cyrtogonium palustre BRACKENRIDGE, U. S. Expl. Exped. 16 (1854) 86, pl. 12, fig. 2.

C. terrestre; stipitibus semiteretibus sulcatis parce paleaceis; frondibus membranaceis glabris pinnatis apice sinuato proliferis; pinnis oblongo-lanceolatis pinnatifidis acuminatis basi oblique cuneatis, laciniis oblongis crenato-denticulatis, fertilibus minoribus oblongo-lanceolatis petiolatis integris.

Hab. Tahiti, Society Islands: in marshy grounds near the coast.

Stipes from 10 to 12 inches in length, *half-round*, with 2 to 3 shallow grooves in front, densely *paleaceous* at the base, towards the summit less so; the paleae oblong, acuminate, reticulate, with a ragged dentate margin. Sterile *fronds* deltoid-oblong, acuminate, *rooting at the apex, smooth, rather membranaceous, pinnate* at the base, *sinuate-pinnatifid* towards the point. Inferior pinnae 4 to 5 inches long and an inch broad, subpetiolate, nearly opposite, *oblong-lanceolate, acuminate, pinnatifid*, with an *oblique cuneate* base; the middle ones adnate and decurrent; while those toward the point are confluent, entire, subfalcate and obtuse. *Segments oblong* or triangular-ovate, the margin denticulate, with a single stiff hair seated at the base of the sinus. *Fertile fronds narrower*, with from 14 to 16 pinnae . . . Veins prominent on both sides, the anastomosing veinlets slender.—BRACKENRIDGE.

From the number of collections, this seems to be a common fern in Tahiti and Samoa. As in various other proliferous species, the apex is variable, sometimes forming a long narrow rooting tail. Samoan specimens too similar to seem specifically different have the sterile pinnæ uniformly wider, more conspicuously falcate-caudate, more deeply cut with narrow, subfalcate lobes, and more numerous areolæ in the uncut lamina.

The terminal segment may be short, 5 to 10 centimeters long, contracted from a broad base, through a short, lobed portion of a few lobes, to a short tail; or it may be drawn out, as in the more attenuate forms of *Campium heteroclitum*, into a sinuate or lobed lash, 25 centimeters or more in length. The pinnæ normally bear a visible excrescence at about the base of the narrow apex of each, showing potential proliferation. A Samoan specimen, collected by Francis C. Prince in 1898, has the tails of the pinnæ drawn out to 5 centimeters or more, and the majority of them bear well-developed little plants.

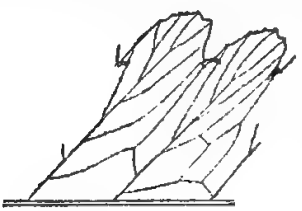


FIG. 25. *Campium palustre* (Brackenridge) Copeland, comb. nov.; Tahiti, *Setchell and Parke 435*.

New Caledonia specimens, *Rosenstock Fil. Nov. Cal. 31*, distributed as *Leptochilus quoyanum*, but better to be called *Campium palustre*, have the lowest pinnæ strongly developed on the lower side, and the veins anastomosing less freely than is typical. I think it very possible that these represent *Chrysodium sagenioides* Kuhn, and abstain from reducing that species to *Campium palustre* chiefly because of Kuhn's description of the venation. *Campium palustre* is represented from Queensland by a specimen collected by Dietrich, United States National Herbarium, No. 269584, distributed "ex museo Godefroy Hamburgensis" as *Chrysodium cuspidatum* Kuhn.

25. CAMPIUM SAMOENSE Copeland, sp. nov. Plate 19.

Species gregis C. quoyani; rhizomate repente, paleaceo, 5 mm crasso; stipite frondis fertilis 50 cm alto, gracile, fulvo, ad pedem paleis fusco-fulvis lanceolatis 3–5 mm longis vestito, alibi rhachique glabrescentibus; frondis sterilis verisimiliter parte solummodo in manubus 30 cm longa, ultra 20 cm lata, pinnis inferioribus 13 cm longis, 2–2.5 cm latis, basi subsessilibus utrinque late (et basiscopice latius) cuneatis, apice caudatis cauda breve aut recta aut falcata anguste lineare late crenata, margine oblique haud profunde inciso-lobatis lobis integris sinubus acutis interdum dente spiniforme munitis, membranaceis, quoad laminam glabris, brunnescenti-viridibus, costis gracilibus inferne paleis minutis ornatis, venatione C. quoyani venulis tenuissimis inferne conspicuis; segmento terminale frondis breve, pinnatifido lobis ovatis falcatis, in caudam 25 mm longam in specimine non proliferam desinente; fronde fertile 30 cm longa, 15 cm lata, apice composita, pinnis utroque latere ca. 10, infimis 9 cm longis, 9 mm latis, stipitulatis, longe sensim acuminatis,

deorsum late crenatis cum spina in sinu quoque, superioribus integris vel similiter spiniferis absque crenatione ulla, infernè tota latetudine sporangiis obtectis.

Samoa, *Rev. T. Powell.* Type in the Gray Herbarium.

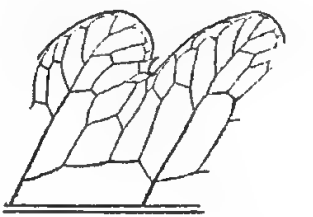


FIG. 26. *Campium samoense* Copeland, sp. nov.; type.

A relative, more particularly, of *Campium palustre*, as indicated by the oblique lobes, but differing in the broader base of the longer, narrower sterile pinnæ with parallel sides, less abruptly narrowed to narrower, shorter, nonentire tips, conspicuous veinlets, brownish green color, and most conspicuously in the long, narrow, fertile pinnæ. From *Campium quoyanum*, it differs in the more cuneate base of the sterile pinnæ, shallow, entire lobes, and long-pointed, more entire, fertile pinnæ.

26. CAMPIUM RIVULARE (Brackenridge) Copeland, comb. nov. Plate 20.

Cyrtogonium rivulare BRACKENRIDGE, Bot. U. S. Expl. Exped. 16 (1854) 85, pl. 11, fig. 2.

C. rhizomate repente; stipitibus angularibus paleaceis; frondibus membranaceis glabris oblongis attenuatis basi pinnatis versus apicem sinuato-pinnatifidis, fertilibus minoribus; pinnis integris oblongo-lanceolatis vel ovatis obtusis subfalcatis apice proliferis.

Hab. Ovalau, Feejee Islands: banks of streams, on wet rocks, in shady places.

Rootstock creeping, about the thickness of a goosequill, and paleaceous; the paleae reticulate, ovate-oblong, attenuate, dentate. *Stipes angular*, slightly furrowed, 4 to 5 inches long; that of the fertile frond 12 to 14 inches long, and, together with the rhachis, bearing slender *rufous paleae*. *Sterile fronds* 8 to 10 inches long, smooth and *membranaceous, oblong, attenuated*, the base *pinnate*, towards the apex *sinuato-pinnatifid*, the latter with the obtuse points of the pinnae *proliferous*. *Fertile fronds small*, not exceeding 4 inches in length, with the points of the *pinnae oblong-lanceolate or ovate*, more rounded than in the sterile ones.—BRACKENRIDGE.

As this is not represented among the numerous Fiji ferns in local herbaria, I conclude that it is not common; but this kind of question, as to Fiji, is expected to be answered by the careful collection now undertaken by the Bishop Museum.[19] Brackenridge's plate shows a very distinct species, with a single pair of free pinnæ; less than half of the lobes of the body of the frond are proliferous.

[19] These collections are now in hand and show that *Campium rivulare* is a clear-cut and distinct species, but that in its full development it has many pinnæ and is not remarkable for the production of numerous buds. Venation and shape of pinnæ are substantially as described by Brackenridge.

Beside the type, the only specimen I have seen is a sterile one from Fiji, *Horne 694*, in the Gray Herbarium, collected in 1877–1878. It has one pair of stipitulate pinnæ, the next two or three pairs adnate, and the rest of the frond coadunate, lobed or pinnatifid but not nearly to the costa. It is much broader than the specimen figured by Brackenridge, the basal pinnæ reaching a length of 10 centimeters. Also, no pinnæ are actually proliferous. Still, the almost entire bluntish pinnæ and lobes, the large, shallowly lobed or pinnatifid upper part of the frond, and the venation make the identification positive. The main veins are very weakly developed.

27. CAMPIUM NEGLECTUM (F. M. Bailey) Copeland, comb. nov.

Acrostichum neglectum F. M. BAILEY, Proc. Linn. Soc. N. S. Wales 5 (1881) 32; Syn. Queensland Flora (1883) 722.

Rhizoma squamosum, fuscum, durum, Lomariae simillimum, frondibus fertilibus et sterilibus 1′ ad 3′ alt. lanceolatis, profunde pinnatifidis, segmentis angustis, linearibus, marginatis. Stipite frond. steril. alibus dentatis vel lobatis marginatis, segment. lanceolatis, serratis, dentibus serratis vel aculeatis, long. 3″ ad 6″, lat 6‴ ad 9‴. Alae supradictae lat. 6‴. Venis ut in A. repandum.

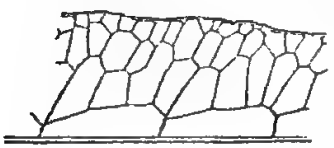


FIG. 27. *Campium rivulare* (Brackenridge) Copeland, comb. nov.; Fiji, *Horne 694*.

In vallis perumbrosis, Trinity Bay Range.

Rhizome creeping, scaly, dark coloured, hard. Fronds of two kinds like a *Lomaria*, one to three feet high, lanceolate in outline, deeply pinnatifid, stipes in the fertile frond more than half its length, and bordered by a narrow wing . . . Stipe of the sterile frond half the length of frond, bordered by a toothed or lobed wing to the base . . .—BAILEY (1881).

The English translation is copied verbatim in the synopsis of the Queensland Flora.

Icones: Hooker's Ic. Plant. III 7: pl. 1689, with a modified Latin description; Bailey, Lithograms of the Ferns of Queensland, pl. 185.

Bailey, beside noting a resemblance to his *Acrostichum repandum*, refers to a specimen so named in the herbarium of J. Smith. Baker says "it comes nearest to the widely spread A. virens." It differs from either of these conspicuously enough to make me suspicious as to the genus.

28. CAMPIUM TAYLORI (F. M. Bailey) Copeland, comb. nov.

Acrostichum Taylori Bailey, Rep. of Ql. Accli. Soc. April, 1884. Fronds scaly, somewhat tufted from a short, creeping, knotted rhizome, stipes of fertile fronds from under 2 inches to 5 inches long, slender, those of the sterile fronds usually shorter; fronds pinnate in the lower, pinnatifid in the upper part, and usually terminating in a narrow, tail-like, proli-

ferous apex; pinnae obtuse-oblong, very irregularly lobed, 1 to 3 inches long, 3 to 9 lines broad. Veins forming a row of long costular areolæ, the rest free to the margin.

Hab.: On wet rocks, Johnstone River.

Very near *A. repandum* Bl., but a much smaller plant with a closer habit.—F. M. BAILEY, Synop. Queensland Fl. Suppl. 1 (1886) 65.

Not seen. So far as explicit statements go, nothing in the foregoing description except the "closer habit" would distinguish this from *Campium argutum*, which is very lax in its fully developed form. Bailey [20] figures this, showing rounded apices of pinnæ and lobes; the pinnæ lobed a third of the way to the costa or the basal ones half-way; lobes about four on each side, almost entire except for the tooth in the sinus; pinnæ, three pairs stalked and one pair adnate, below the pinnatifid apex, which is half of the length of the frond.

29. CAMPIUM PARVUM Copeland, sp. nov. Plate 21.

C. nanum gregis C. quoyani, rhizomate repente, 2 mm crasso, paleis fuscis ovatis, acuminatis, 1 mm longis obtecto; stipitibus seriatis, gracilibus, minute sparse paleatis, frondis sterilis usque ad 4 cm, fertilis ad 9 cm altis; fronde sterile 5–6 cm longa, ovato lanceolata, pinnata, rhachi anguste alata, parte terminale e pinnis coadunatis confecta; pinnis utroque latere 2 vel 3, infimis stipulatis, late ovatis, obtusis vel rotundatis, basi dilatatis sed decurrentibus, interdum obscure paucilobatis, irregulariter dentatis dentibus rarissime apiculatis; venis inconspicuis, extra areolas costales irregulariter anastomosantibus, venulis liberis inclusis nullis; fronde fertile conforme minore, 3.5 cm longa, 1.5 cm lata, pinnis infimis sinuato-lobatis.

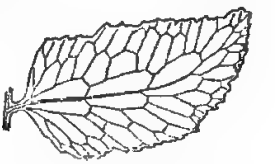


FIG. 28. *Campium parvum* Copeland, sp. nov.; type.

Kaiser-Wilhelms Land, in mountain woods, altitude 300 m. s. m., *Schlechter 16163*, 1907. Type in the herbarium of the University of California, No. 226411.

This was distributed as *Leptochilus inconstans*, which it resembles in hardly any respect independent of size. This is certainly one of the *C. quoyanum* group, as shown particularly by the fused pinnæ composing the upper part of the frond. The single pinnæ are too small to develop main veins, but the larger, upper part of the frond shows the venation of the pinnæ of the larger species of the group.

[20] Lithograms of the Ferns of Queensland (1892) pls. 183, 184.

A sterile specimen from Papua, *King 269*, 1909, is possibly the same as this, but its stipes are persistently densely scaly.

38. CAMPIUM ARGUTUM (Fée) Copeland, comb. nov. Plate 22.

Heteroneuron argutum FÉE, Acrost. (1845) 96, pl. 25, fig. 2.

Frondibus sterilibus basi bipinnatifidis, apice pinnatis, frondulis basilaribus laciniis suboppositis, curvatis, inciso-dentatis, dentibus argutis, rhachi subnudo, plano; fertilibus pinnatis, pedicellatis, frondulis in apice ovato coalitis, primariis pinnatifidis, petiolo universale (rhachi) plano; rhizomate repente, flexuoso, fibrilloso, crassitie pennae columbae; sporangiis rotundis, late pedicellatis, annulo 13–14 articulato, sporis magnis, rotundatis, episporio persistente.

Habitat in Manila, nec non in Philippinis, Luçon (Cuming).

Exsiccatum: Cuming no. 161, non no. 105.

. . . M. Kunze, qui a vu notre spécimen, le déclare jeune.—FÉE.

This has remained a doubtful species since the time of Fée, except for additional and accurate notes by Presl,[21] who called attention to the mixture under Cuming's number. *Cuming 161* in the United States National Herbarium is typical. Probably the same as this are plants recently brought in by Dr. F. T. McLean. Because these represent the plant in a really mature form, on which the description ought to be based, a description fitting them follows:

Rhizomate repente, 2–3 mm crasso, paleis nigro-fuscis parvis tecto; stipitibus approximatis, sordide stramineis, frondium sterilium 20 cm, fertilium ca. 35 cm altis, paleis paucis angustis 3–5 mm longis aliisque minutis vestitis, glabrescentibus; fronde sterile ca. 25 cm longa, ovata, subbipinnata, lamina glabra, herbacea, laete viride; pinnis liberis ca. 6-paribus, infimis longe (1 cm) stipitulatis, caudatis, profunde pinnatifidis, lobis obtusis, falcatis, serrulatis, infimo interdum libero (deinde pinnula), sinu quoque unilateraliter dente uno acuto ornato, parte apicale frondis e segmentis coadunatis composita, frondibus visis non proliferentibus; venulis ob dissectionem frondis saepe liberis, areolis paucis et irregularibus; pinnis fertilibus crenato-sinuatis, 2–4 cm longis, 3 mm latis, infimis interdum majoribus et pinnatifidis.

FIG. 29. *Campium argutum* (Fée) Copeland, comb. nov.

LUZON, Cagayan Province, Claveria, *McLean, Catalan, and Peralta s. n.*, 1920, *McLean and Catalan s. n.*, 1919.

A member of the group of *Campium quoyanum* as to conspicuous characters, differing from that species in the greater dissection, and in the narrower and more uniform pinnæ.

[21] Epim. 169.

31. CAMPIUM BIPINNATIFIDUM (Mettenius) Copeland, comb. nov.

Chrysodium bipinnatifidum (Boivin) METTENIUS in Kuhn, Fil. Afr. (1868) 50.

Rhizoma repens, validum, paleis lanceolatis, fuscis squamosum; folia membranacea, firma, supra opaco-viridia, infra ad costas paleis paucis squamulosa, sterilium petiolus 5" longus, stramineus, rhachis marginata; lamina 9" longa, ovata, acuminata, pinnatisecto-pinnatipartita s. basi deorsum subbipinnatisecta; supra sub apice e costa prolifera; segmenta patentia, e basi inaequali, superiore truncata s. subcordata, inferiore cuneata s. rotundata, elongata, attenuata, infima brevi petiolulata, superiore basi deorsum adnata s. decrescentis, suprema in apicem pinnatifidum confluentia, lobi laciniaeve ala manifesta coadunatae, semioblongo-ovatae s. elongato-oblongae, serratae; dentes herbacei, obtusi s. acuti, basales interni ad sinus loborum maximi; nervi in pagina inferiore manifesti, catadromi; maculae ad sinus laciniarum bi-subtriseriatae, secus costulas uniseriatae.

Ins. Sechellae (Boivin).—Ins. Borboniae (Boivin).—KUHN.

I now think that this can safely be regarded as a species distinct from the Asiatic and Polynesian *L. cuspidatus* C. Chr. (*Acrostichum repandum* Blume). It differs in the more deeply cut pinnae, which are truncate at the base, not cuneate, and in the more decidedly scaly costae. The lowermost pinnae are rather unequal-sided, the upper ones decurrent at the lower base, and the fertile pinnae deeply cut into bluntly rounded lobes. The sterile fronds often have rooting tips.—CHRISTENSEN, Trans. Linn. Soc. Bot. 7 (1912) 414.

These distinctions may apply to the *repandum* form better than to typical *C. quoyanum*.

This is the most western species of its group.

A specimen from the Seychelles in the Gray Herbarium conforms perfectly with Mettenius's description in all respects except size, being more than 40 centimeters long (the sterile lamina), and also broadly ovate. The lowest two or three pairs of pinnæ are stalked, the middle ones adnate on the lower side, and in the upper third of the frond coadnate, but connected by a narrow wing. The lowest ones are narrowed to the base, with a single small, oblong, almost free segment. In general aspect, it suggests a *Pleocnemia*. However clearly a member of the same group, it is very distinct from *Campium quoyanum*, and, because of the deep dissection of the pinnæ, especially so from the Javan, *repandum*, form. It is distinguishable from all other known species by the broad areolæ, with free included veinlets, between the sinuses and the costa. In the specimen referred to, the subject of the accompanying drawing, these

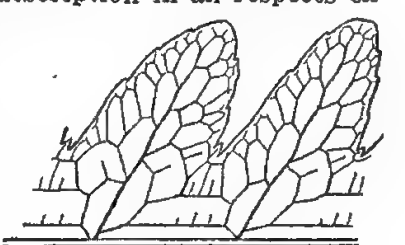


FIG. 30. *Campium bipinnatifidum* (Mettenius) Copeland, comb. nov.; Seychelles.

areolæ are further remarkable because of their free included veinlets. These veinlets are almost wanting in a United States National Herbarium specimen, No. 815186, collected by Neville, which has the frond longer, not quite so wide, less dissected, and terminating in a linear lash more than 20 centimeters long, proliferous at both apex and base.

32. CAMPIUM BOIVINI (Mettenius) Copeland, comb. nov.

Chrysodium boivini METTENIUS in Kuhn, Fil. Afr. (1868) 51.

Rhizoma?; folia chartacea, opaco-viridia, glabra; sterilium petiolus 9″ longus, livido-stramineus; lamina 10″ longa, ovato-acuminata, pinnatisecta, apice pinnatifida, supra sub apice prolifera; segmenta 3–4-juga, approximata, patentia, lanceolato-oblonga, acuminata, integerrima, infima breviter petiolata, basi superiore truncata, inferiore cuneata, superiore brevius petiolata vel basi inferiore decurrente adnata, utrinque cuneata, suprema in apicem basi pinnatipartitum confluentia, aciniis 3-jugis, sinubus acutis distinctis, oblongis, acuminatis falcatis, infimis, maximis decurrentibus; costulae manifestae, vix prominulae, maculae utrinque ad costam irregulariter 3–5-seriatae, costulae amplae, plerumque appendiculatae, ceterae appendiculatae vel radiatae vel in maculas secundarias divisae; arcus Pleocnemiae inter lacinias coadunatas, exappendiculatas, macularum series ad sinus laciniarum 2–3 irregulares appendiculatae; fertilium? (Mett. msc.)

Ins. Comorae; ins. Mayotte (Boivin).—Angola (Welwitch, Iter Angolense n. 156).—KUHN.

Since reported from the Belgian Congo and elsewhere in Africa. According to Engler [22] *Acrostichum laurentii* Christ is identical with this.

I have seen no specimen. It is placed in the *quoyanum* group because a fern pinnate below and pinnatifid at the top seems to belong there. The group is represented positively in the Seychelles by *Campium bipinnatifidum*.

33. CAMPIUM SEMICORDATUM (Moore: Baker) Copeland, comb. nov. Plates 23 and 24.

Acrostichum semicordatum BAKER, Syn. Fil. (1868) 422.

Rhizome woody, short-creeping; *st.* of barren fr. 6–8 in. l., erect, nearly naked; *barren fr.* 8–12 in. l., 3–4 in. br., sometimes proliferous at the apex; lower *pinnae* 2–3 in. l., ½–⅔ in. br., the edge inciso-crenate throughout, the base cordate on the upper, truncate on the lower side; *texture* herbaceous; *surfaces* naked; *veins* fine, the main ones distinct about halfway to the edge, the *areolae* in 3–4 rows, with free veinlets; *barren pinnae* (this surely should read *fertile*) distant, 1–1½ in. l., 1 lin. br.—*Poecilopteris semicordata, Moore. Hk. 2nd Cent. t. 88.*

Hab. Concan, *Law;* Neilgherries, *McIvor;* Ceylon, *Thwaites 3075.*—BAKER.

[22] Pflanzenwelt Africas 16.

The illustration in Beddome [23] is a drawing by Baker from McIvor's collection, which does not conform well to the written description. The margin of the sterile pinnæ is depicted as finely and acutely serrate, more so than any specimen I ever saw in the genus; the venation is drawn with uniformly two rows of areolæ, and the fertile pinnæ as drawn are up to 5 millimeters in width. There is also a detail drawing of the fructification, representing the sporangia as confined to a broad middle zone, with the margins sterile. Beddome had never seen such a fern, but suspected it of being a form of what he called *Poecilopteris contaminans.*

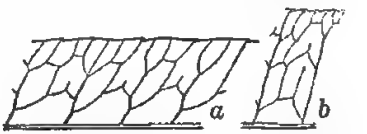


FIG. 31. *Campium semicordatum* (Moore: Baker) Copeland, comb. nov.: a, cotype; b, India, *Beddome.*

I have from the Gray Herbarium, but not from Kew, a specimen, the subject of the right half of the accompanying Plate 23, which I construe as a cotype of this species, Law's collection being the first cited by Baker. I do not try to decide wether or not the other specimens cited by Baker are the same; but, if I ever see a fern with the fertile frond as it is figured in the Beddome plate referred to, I will consider it distinct.

With this, I identify a fern collected by Beddome, which I considered different before receiving the Law specimen. To give a more complete idea of the species, I will still publish the description and plate prepared while I deemed it distinct.

Rhachi paleis minutis atrocastaneis persistentibus sparse vestita; frondis sterilis pinnis multis, fere contiguis, late lanceolatis, acutis vel acuminatis, minute et obtuse serrulatis, basi obliquis acroscopice rotundatis basiscopice cuneatis, viridibus, papyraceis, foliola terminale moderatim elongata, crenato-lobata; costa inferne prominente; venis inconspicuis; venulis reticulum areolarum typice triseriatarum (vena ad venam) efficientibus sed hic illic infra confluentiam normalem desinentibus, liberis marginem versus (nec usque) currentibus brevibus, clavatis.

India, Anamallay, altitude 600 to 1,200 m. s. m., *Capt. Beddome.*

This is probably a very common Indian fern, without an early valid name because of long confusion and misidentification. I take this to be *Acrostichum contaminans* of Beddome, at least in large part, and of Wallich, as represented by a specimen of his No. 22 sent me from Kew, but not as interpreted by Clarke.

[23] Ferns of British India pl. 270.

I also take it to be the fern repeatedly called *Acrostichum repandum*, illustrated by Beddome;[24] but it is not at all *A. repandum* Blume. Less confidently, I take it to be *Polybotrya prolifera* Bory, *Heteroneuron proliferum* Fée, Acrost. pl. 55, fig. 1; but this name is preoccupied in *Campium* by Presl's transfer of *A. proliferum* Hooker, which is a synonym of *C. subcrenatum* and a homonym of *A. proliferum* Blume. *Acrostichum terminans* Wallich, List No. 2168/1, is this or a very nearly related species; it has a very elongate apex, bearing exceedingly many little lobes or, in its lower part, pinnæ.

34. CAMPIUM LANCEUM Copeland, sp. nov. Plate 25.

Rhizomate repente, 1 cm crasso, paleis fuscis anguste lanceolatis 3–4 mm longis vestito; stipitibus approximatis, 60–70 cm altis, sursum rhachique trisulcatis, decidue squamulosis, fulvo-stramineis; frondis sterilis parte inferiore solummodo visa 30 cm longa; pinnis suboppositis, valde (5–8.5 cm) inter se remotis, longe (infimis 15 mm) pedicellatis, 25–30 cm longis, 25–30 mm latis, basi subaequaliter anguste cuneatis, apice sensim longe attenuatis et ibidem dentibus appressis apiculiformibus praeditis haud proliferis, margine alibi crenato-undulatis, laete viridibus, glabris, papyraceis; costa utraque facie prominente; venis infra marginem dissipatis, areolis quae nec costam nec venas attingunt irregulariter 1–2-seriatis, venulis liberis inclusis paucis; fronde fertile 30–40 cm longa; pinnis utroque latere ca. 10, brevius stipitulatis, usque ad 10 cm longis, 3 mm latis, integris, terminale conforme elongata, gemmulifera.

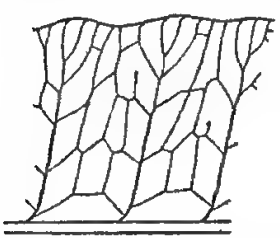


FIG. 82. *Campium lanceum* Copeland, sp. nov.; type.

Madras, Rumpa Hills, altitude 900 m. s. m., *Gamble 15921*. Type in the Kew Herbarium.

This seems to have been distributed as *Gymnopteris subcrenata* Hooker and Greville, from which the slender, long-stalked, sharp-based sterile pinnæ and very different venation mark it off clearly. In much the same respects it differs from *Campium semicordatum*, to which it seems rather closer. The old species to which it is really near is *C. undulatum*, to which, if without any respect for the peculiarities of fertile fronds, I might refer it.

[24] Ferns of Southern India pl. 202.

35. CAMPIUM ANGUSTIPINNUM (Hayata) Copeland, comb. nov.

Leptochilus angustipinnus HAYATA, Icones Fl. Form. 5 (1915) 297, fig. 119.

Leptochilus cuspidatus var. *crenatus* ROSENSTOCK, Hedw. 56 (1915) 348; HAYATA, Icones 8: 150.

Rhizoma? Frons sterilis: Stipes 30 cm. longus medio 2½–3 mm. latus basi minute densiuscule squamatus, squamis polygono-oblongis subamoeboideis 1 mm. longis ½ mm. latis, stramineus plano-convexus in sectione supra planus subtus convexus supra 4–5 sulcatus; frons ovato-triangularis 45 cm. longa 30 cm. lata medio latissima basi minus lata vel aequilata vel latior apice caudato-acuminata basi in ambitu truncata pinnata, pinnis linearibus infimis 16 cm. longis, pinnis mediis subaequilongis superioribus gradatim brevioribus minoribus, versus apicem frondis ad pinnas laterales superrimas minimas 4–5 cm. longas abeuntibus; pinna terminali subito longior pinnas superrimas laterales in longitudine 3–4-plo superanti vel interdum perfecte obsoleta et ad prolem reducta; pinna infima lineari 15–16 cm. longa 2 cm. lata apice gradatim acuminatissima, acuminibus minus quam 3 mm. latis 2 cm. longis, medio deorsum aequilata basi late triangulari-acuta margine repandula, repandulis mediis 4 mm. latis 1½ mm. longis apice rotundatis plus minus ascendentibus; pagina membranacea vel tenuiter chartacea supra glabra subtus ad vel prope costas leviter tenuiterque minute squamata, in exsiccato viridescens, costis venis utraque pagine elevatis tenuissimis gracillimis, venis a costa angulo 60° egressis, venulis gracillimis sub luce transversa distincte visis reticulatis, reticulis costalibus mediis triangularibus 5 mm. longis 1½ mm. latis, venis lateralibus mediis 5 mm. a se remotis; pinnis alternis mediis a se (utroque latere) 2½–3 cm. remotis, pinnis inferioribus breviore petiolulatis, mediis superioribus subsessilibus vel sessilibus, pinnis inferioribus a rhachide frondis angulo obtuso, pinnis mediis superioribusque a costa angulo 45° egressis; rhachis frondis dorso complanata plus minus minute squamata medio 1–1½ mm. lata supra sulcata ad medium sulcorum tenuiter costata, costis venis venulis pinnarum utraque tenuiter elevatis, venulis anastomosantibus. Frons fertilis cum ea sterili aequilonga aequilata, pinnis angustissimis linearibus 15 cm. longis 7 mm. latis apice angustissimis basi triangulari-acutis subsessilibus vel breve petiolatis (petiolis 1–2 mm. longis) margine leviter regulariter lobulatis vel repandulis, lobulis 1½ mm. longis 3½ mm. latis apice rotundatis; costa supra elevata, venis supra elevatis a costa angulo recto egressis vermiforme recurvis, venulis reticulatis. Frons per totam paginam densissime sorifera.

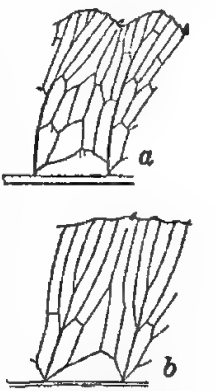


FIG. 33. *Campium angustipinnum* (Hayata) Copeland, comb. nov., *a*, Formosa, *Faurie 281*; *b*, Sikkim, *Jerdon*.

Hab. Prope Hokkokei, leg C. Owatari. Jan. 1898. . . .

Near *Leptochilus virens*, but separable from it by the much longer and narrower pinna.—HAYATA.

As far as it goes, this is the most complete description ever given to *Acrostichum virens* of Synopsis Filicum, which differs from the Formosa plant, if at all, only in the details of the venation. Of Rosenstock's variety, we have a cotype. It is unrelated to either *Campium cuspidatum* or to *Leptochilus cuspidatus* of Christensen, but fits Hayata's description in everything except size. The stipes are 75 centimeters long and 7 millimeters in diameter, and the frond correspondingly large; between this and the figures of Hayata, lies the usual range of "*Acrostichum virens*." The accompanying figures show the venation of Formosan and Sikkim plants.

It has been noted by both Clarke and Beddome that the original sheet of *Acrostichum virens* Wallich is a sheet of blank paper. The original entry of it, Wallich List, page 29, is:

1033 *Acrostichum virens* Wall. Tavoy W. G. (coetera spec. No. 13 &c.)

On page 64 of the List, as a correction, one reads:

1033 Dele Acrost. virens quod est idem ac Taenitis v. Nothol. undulata (140).

The sheet of No. 140 sent me from Kew contains, as an addition, a plant of this species, collected by Griffith, which I thought might be the missing *Acrostichum virens*, the "W. G." of the original entry being the collector's initials; but Griffith's obituary in the Journal of Botany says he did not go to India until 1832.

The *Acrostichum virens* of Synopsis Filicum would have made an interesting herbarium by itself, and in Christensen's Index it gains about as much as it loses. Clearly comprehended in it, and so determined, is a plant collected in Sikkim by Doctor Jerdon, evidently a very large fern, of which I have only the upper 50 centimeters of the sterile frond, with a longer, complete fertile frond. Assam specimens, collected by Gustav Mann, distributed as *Gymnopteris contaminans*, are identical with Jerdon's. Except that there is much less anastomosis of the veinlets, it is indistinguishable from Faurie's Formosa specimen. Having a single specimen of each and no opportunity to study the variability, I am calling them the same. The range of *Campium angustipinnum* thus seems to be from Sikkim to Formosa.

36. CAMPIUM CRISPATULUM (Wallich) Presl. Plate 26.

Campium crispatulum PRESL, Epim. Bot. (1849) 171.
Acrostichum crispatulum WALLICH, List No. 24; CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 580.

Barren pinnæ numerous, often 20 or more, 4 by ½ in., slightly serrate, the midrib often reddish when dry, a series of costal arches without in-

cluded veins along their midribs, no free veins in any of the areolæ; fertile pinnæ 4 by ⅛–¼ in.—*A. virens*, var., Hook. Sp. Fil. v. 261; Hk. & Baker, Syn. Fil. 420. (Pl. LXXXIV. fig. 2, *b*, *d*.)

Round Bengal from Kumaon to Bhotan and Chittagong in the lower hills, alt. 0–3000 feet, common.

The only very common Bengal species of the group called *A. virens* by Mr. Baker. Very constant in character, and easily recognized by the absence of free veins.

Var. *contaminans*, Wall. Cat. 22. Barren pinnæ often ¾–1 in. broad, more crenated, green or yellowish; fertile pinnæ ⅛–¼ in. broad. (Pl. LXXXIV. fig. 2, *a*, *c*.)

Grows with the preceding; a trifling variety.—CLARKE.

This is indeed a very distinct species, characterized by the size, shape, margin, and color of the sterile pinnæ, the terminal quite like the lateral ones, and by the venation. What Clarke meant to say is that there are no *included* free veinlets; the conspicuous feature is the length of the free veins running to the margin. The specific name accurately describes the overfull margin. The color is that of *Campium scalpturatum*, which is distinct enough in other respects.

FIG. 34. *Campium crispatulum* Presl; Kamoun, *Wallich 24*.

As to *Acrostichum contaminans* Wallich: The Wallich specimen sent me from Kew is not at all this species, but is *Campium semicordatum*, as Beddome construed it. Using this name, Clarke figured a fern with pinnæ nearly 20 centimeters long, quite different from that to which Beddome applied the name.

37. CAMPIUM SCALPTURATUM (Fée) Copeland, comb. nov.

Heteroneuron scalpturatum FÉE, Acrost. (1845) 95, pl. 56.

Frondibus sterilibus pinnatis, glabris, frondulis oblongo-lanceolatis, brevissime petiolatis, acuminatis, margine crenato, crenis laceris, incisis, basi cuneatis, mesoneuro nervillisque rubris; frondula terminali longissima, undulata, vivipara; fertilibus pinnatis cum impari, mesoneuro ac nervillis prominentibus, frondulis petiolatis, linearibus, coriaceis, supra duos margines canaliculorum rhachium explicatis, margine undulato, crenato, crenis dentatis, saepe reflexis, basi anguste cuneatis, apice longe acuminatis, petiolulo brevi; rhachi compresso, fasciculos duos vasorum internos includente, inferne subplano, obscure canaliculato superne trisculcato; rhizomate crasso, irregulari, fibris longissimis; sporangiis subrotundis, pedicello lato donatis, annulo 16 articulato, sporis irregularibus, succineis, ovoideis angulatisque.

Habitat in India occidentali, Nepaul, Sylhet (Wallich); Manilla (Gaudichaud, Voy. de la Bonite, 1836).—V. S. in herb. Bory et Mus. Par., ex Gaudichaud.

Sterile fronds 50 to 60 cm. long, on stipes of 15 cm.; their pinnæ about 10 cm. long by 3 wide; fertile fronds reaching a total height of nearly a meter, their longest pinnæ 24 cm. long.

Cyrtogonium costatum? J. Smith, in Journ. Bot. Hook., IV, 1841. *Acrostichum costatum*, Wall., herb., no. 26.—*Campium*, Presl, Tentam. Pterid., p. 239?—FÉE.

Presl [25] scored Fée roundly for the interrogation points quoted above, stating that both he and Smith had consulted specimens labelled by Wallich himself. As I construe these marks, Fée was questioning the identity of *Campium costatum* and his own species. What he described, and knew positively as *Heteroneuron scalpturatum*, was Gaudichaud's plant, from the Philippines, which must accordingly be regarded as the type. It is a rare fern in the Philippines, light green, except as it is tinged with red, sometimes strongly so. I have not seen Wallich's specimens; but if descriptions, and several named specimens from Kew enable me to judge *Campium costatum*, the two are thoroughly distinct. They have in common a tendency to redness, and perhaps for the sporangia to avoid the middle of the pinnæ, but the venation is very distinct, and *C. costatum* has much larger and broader pinnæ.

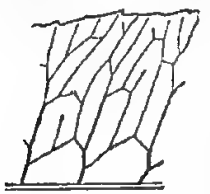


FIG. 35. *Campium scalpturatum* (Fée) Copeland, comb. nov.; Lamao, *Copeland 249*.

It is very much more nearly related to *Campium angustipinnum*, from which it is distinguished by the absence of the latter's many long free veinlets running to the margin, and to *Notholaena undulata* Wallich, as will be noted later. It is the only Philippine representative of the typically Indian group of species. Because of past confusion of species in this group, I do not undertake to state its distribution, if any, beyond the Philippines. A specimen in the Gray Herbarium, apparently from Ceylon, is near to this but hardly identical; it is suggestive also of *Campium semicordatum*. It is probably an undescribed species.

The venation figured is that of a specimen from Lamao, near Manila. Fée's figure is quite exactly duplicated in this respect by *Merrill 7267*, from Palawan. Christensen,[26] following Christ, recognizes a var. *undulatum*, from Koh Chàng.

38. CAMPIUM UNDULATUM (Wallich: Hooker) Presl. Plate 27.

Campium undulatum (Wallich: Hooker) PRESL, Epim. Bot. (1849) 170.

Notholaena undulata WALLICH, Cat. No. 140, nomen.

Jenkinsia undulata HOOKER, Gen. Fil. (1842) pl. 75 B.

[25] Epimeliae 170.

[26] Bot. Tidsk. 32 (1916) 344.

Sorus linearis, elongatus, continuus, nudus, prope marginem avenium frondis difformis.—Filix tropica, Indica. Frondes pinnatae. dissimiles, foliolis lanceolatis undulato-dentatis coriaceo-membranaceis, saepe proliferis, fertilibus angustioribus, pinnis lato-marginatis. Venae pinnatae, subtus praecipue prominentes, parallelae, strictae. Venulae oppositae, in arcus biangulatos confluentes, venulis secundariis ex angulis arcum liberis apice clavatis, aut in sinum arcus superioris in pinnis fertilibus excurrentibus (marginantibus liberis nudis) in sterilibus omnibus usque ad marginem liberis.

Jenkinsia undulata.—(Tab. LXXV. B.)—HOOKER.

It will be noted that, in form, there is no specific diagnosis, except as the plate and the reference to it may constitute one. The real diagnosis of the species is presented in the diagnosis of the monotypic genus, which identifies the species much better than do the most of the specific diagnoses of a century ago.

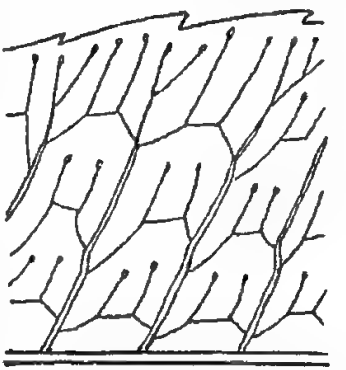


FIG. 86. *Campium undulatum* (Wallich: Hooker) Presl; drawing after Hooker.

It is related to *Campium virens*, confusion with which extends back even to Wallich; see remarks under *Campium angustipinnum*. In spite of Beddome's statement [27] that *Campium deltigerum* and *C. undulatum* "are only abnormal forms . . . . and cannot be recorded as varieties," it should be clear that the restriction of the sporangia to a part of the area can be a valid specific character of some species, and occur as a rare variant in others. The question is one of fact, not of theory. Judging by the Kew material, my belief is that in this instance the restriction of the fructification is the most conspicuous characteristic of a species less conspicuously distinguishable in other respects. A similar restriction of the sporangia is common in *Campium scalpturatum*, which is very distinct in venation and color.

Campium undulatum is known only from the region of its first collection, Martaban.

The accompanying detail of venation is copied from Hooker's plate. My drawing from a Kew specimen has been mislaid; but it is photographed with the Hooker herbarium plant, on Plate 27, and is more than reasonably unlike Hooker's figure.

[27] Ferns of British India and Ceylon 438.

39. CAMPIUM COSTATUM Presl.

Campium costatum (Wallich nomen nudum) PRESL, Tent. Pterid. (1836) 238.

Fasciculi vasorum stipitis in C. costato octodecim, duobus primariis anticis oblongo-compressis. Venae in C. costato subtus elevatae et costaeformes.—PRESL.

Throughout the history of descriptive or systematic or taxonomic botany, a diagnosis has been whatever would suffice to distinguish the plant in question from any other with which it might be confused. This is and always has been accomplished in major part by the reference of the plant to its genus; and the whole demand on the specific diagnosis has been that it suffice to identify the plant within the genus. This was accomplished by the two statements just quoted. It is granted that Presl was not trying to present a diagnosis; but that was because, in common with the most of his contemporaries, he considered the species already published in valid form in Wallich's list. We may reasonably rule that Wallich's names are nomina nuda, but it is neither reasonable nor seemly for us to be very critical in passing on the sufficiency of anything that can possibly be construed as a diagnosis. It is their common fate to be found inadequate, as more species are discovered or recognized, or as we make finer distinctions between what we are pleased to construe as species. Our own species and diagnoses fare in the same way; and it is to be doubted if even such elaborate and comprehensive disquisitions as Hieronymus published in the place of diagnoses will protect his species against future analysts. By word and by drawing, Presl distinguished *C. costatum* from any other *Campium* known to him; and that was enough.

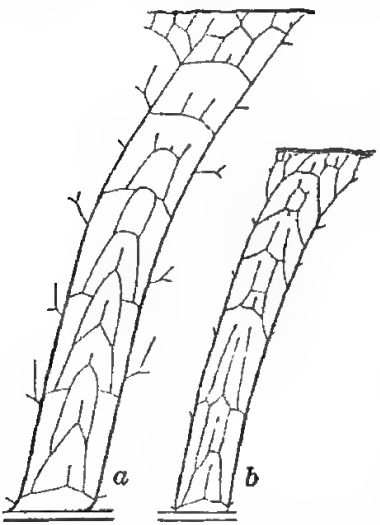


FIG. 37. *Campium costatum* (Wallich) Presl; *a*, from Assam; *b*, from Chittagong.

Barren pinnæ about 11, 8–14 by 2–2¾ in., caudate, stout in texture, drying red, costal arches none or obscure from the presence within them of other veins; secondary areolation copious, with included free veins; fertile pinnæ 6 by ¼–½ in.—Hook. Sp. Fil. v. 262 as to var. ∝ only. *Pœcilopteris costata* Bedd. Ferns Brit. Ind. t. 113.

Round Bengal in the lower hills, alt. 0–3000 feet; from Nepaul to Chittagong, common.

One of the best marked among the Indian *Acrostichums*: its large size, its drying red, its want of costal arches to the midribs of the barren pinnæ, easily distinguish it from all others. It has been joined with *Meniscium deltigerum*, Wall., and with *Acrostichum virens*, Wall., and the descriptions founded on material thus jumbled are not intelligible, but the fern itself is.—C. B. CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 581.

I have quoted Clarke, as one exceptionally familiar with these ferns and at the same time having full herbarium and library facilities for their correct identification. However, on the basis of specimens which he too had in hand, I must correct his observations as to the costal areolæ; these are present, as in all related species, and as shown in the accompanying drawings. Of these drawings, one, from an Assam specimen, shows an almost complete development of median areolæ, showing a clear relation to the venation of *Campium heteroclitum;* the other, from a Chittagong specimen, shows incomplete anastomosis of the veinlets which might form these areolæ, and consequent abundance of free included veinlets, its venation thereby verging toward that of *Campium subcrenatum*, and the species with typical goniopteroid venation. Presl's figure [28] shows the venation of the fertile pinna. I find the free excurrent veinlets more numerous than he shows them, but the difference is not such as to raise any question as to the identity of his fern and Clarke's and mine.

This is the most distinctly coriaceous species in the genus; *Campium subsimplex* may be thicker, but is more fleshy. The frond is opaque with ordinary light, but the venation is remarkably clear and conspicuous when strong light is passed through it. The pinnæ are strongly caudate, commonly with a bud near the base of each tail, or still lower down. The terminal leaflet is like the others but moderately larger, and its bud is more likely to become a plant.

40. CAMPIUM DELTIGERUM (Wallich) Copeland, comb. nov.

Meniscium deltigerum WALLICH, List (1828) No. 59; HOOKER, Spec. Fil. 5 (1864) 262, sub Acr. costato; CLARKE, Trans. Linn. Soc. Bot. 1 (1880) 572.

Small, sori partial generally marginal and interrupted; spots or masses forming transverse lines between the costules frequently having a deltoid form.—HOOKER.

[28] Tentamen pl. 10, fig. 23.

. . . there are no intermediate forms [between this and *Acr. virens*], and the fertile pinnæ are only slightly dimorphous. Col. Beddome's figure [Ferns Brit. India pl. 114] unfortunately does not show the main veins beneath the fertile pinna, which are very strong and a diagnostic mark.—CLARKE.

In size, form, and texture this has fronds and pinnæ much like those of sterile *Campium subcrenatum;* the veins and the veinlets are rather like those of *C. costatum.* Ignoring everything except the fructification, Beddome [29] says, under his *Gymnopteris costata,* that these "are only abnormal forms, such as occur more or less in nearly all the other species of *Gymnopteris* and cannot be recorded as varieties." Leaving fructification out of account for the moment, this differs from *Campium costatum* in having constantly smaller pinnæ with longer stalks, much broader bases, acute but never caudate apices, rarely proliferous even when completely sterile, less even margin, incomparably thinner, and of clear green color. It is only because the fructification is so remarkable that is distracts attention from all of the other differences, that is has been possible to confuse the two species. As to the fructification, such forms are not known in nearly all species of this genus; they are known in a few, and the tendency to form them is a specific character of such species, just as their constant presence is a specific character of this one.

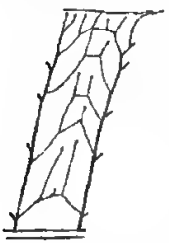


FIG. 38. *Campium deltigerum* (Wallich) Copeland, comb. nov.; Sikkim, *Thomson s. n.*

41. CAMPIUM VIRENS Presl.

Campium virens (Wallich: Hooker and Greville) PRESL, Tent. Pterid. (1836) 239.

Acrostichum virens Wallich: HOOKER and GREVILLE, Icones Fil. 2 (1831) pl. 231.

Frondibus pinnatis (pinnulis subnovem) oblongo-lanceolatis acuminatis membraneceo-coriaceis glabris parallelo-venosis obscure reticulatis cartilagineo-serratis basi oblique cuneatis petiolatis, fertilibus linearibus obtusis, stipite elongato subpaleaceo.

Acrostichum virens. Wall. Cat. . . . No. 1033.

Hab. Tovag in India Orientali (Gul. Govan, M. D.). N. Wallich, M. D.

Caudex oblique repens, crassus, dense paleaceo-squamosus, ...

Stipes pedalis et ultra, semiteres, erectus, sparse squamosus, superne nudus.

Frons late ovata, pinnata; pinnis subnovem, alternis, palmaribus et ultra, oblongo-lanceolatis, membranaceo-coriaceis, glabris, nitidis, pallide

[29] Ferns of British India and Ceylon 438.

virentibus, costatis, pennatim nervosis cum venis anastomosantibus; venulis nonnunquam liberis clavatis; apice attenuatis, marginibus undulatis, paulum incrassatis, remote cartilagineo-serratis, serraturis incurvis, basi oblique cuneatis, in petiolum brevem decurrentibus. *Rachis* glabra, nuda, antice sulcata.

Frons fertilis sterili longior; pinnis brevioribus, linearibus, ad apicem solummodo serratis, obtusis.

. . . In Dr. Wallich's collection is a species much more nearly allied to it (than *A. scandens*); this is the *A. costatum* of the Catalogue, No. 26, but it is twice the size of the present species; the fronds are more coriaceous, the margins more thickened, not waved and crisped, and destitute of serratures. The colour is also very different, being of a purple hue.—HOOKER AND GREVILLE.

Subsequently, Hooker [30] identified this with *Acrostichum subcrenatum;* and Clarke [31] agreed that the two were hardly separable. The superficial resemblance is indeed strong, but the real affinity of *Campium virens* is to *C. costatum* and *C. deltigerum.* The *Acrostichum virens* of Synopsis Filicum is still different (*Campium angustipinnum* of this revision), and some history of *Campium virens,* real and supposed, is given in the discussion of that species. The *Acrostichum virens* of Wallich will probably remain a mystery, but that described and figured by Hooker and Greville is clear beyond any question. If any other species is identical with it, it is *Campium deltigerum;* and the fertile frond is so constant on the several specimens of that species I have seen, that I see no reason to combine them. The fertile pinnæ of plants reasonably referred to *Acrostichum virens* vary from narrowly linear to nearly a centimeter in width, and are all uniformly fructiferous all over the back. The sterile pinnæ are serrate toward the apex; toward the base, they vary from serrate to practically entire.

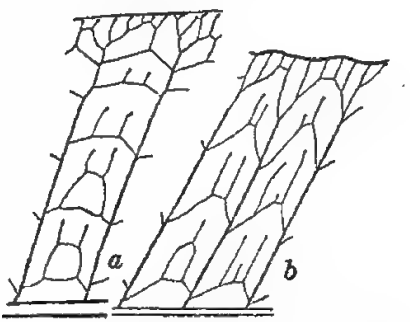


FIG. 39. *Campium virens* (Wallich: Hooker and Greville) Presl; *a,* Sikkim, *J. D. Hooker; b,* Siam, *Eryl Smith 1112.*

As stated by Beddome, *Campium virens* is unknown in southern India. It is found in Sikkim, Burma, and Siam (*Eryl Smith 1112*), and Pinang (*Curtis 628*).

[30] Spec. Fil. 5: 261. [31] Trans. Linn. Soc. Bot. 1: 581.

42. CAMPIUM BRADFORDI Copeland, sp. nov. Plate 28.

Campium C. subcrenato affinis, pinnis paucis frondis sterilis oblongis basi rotundatis margine minute serrulatis, foliola apicale haud flagelliforme distincta, aliter speciei designatae similis.

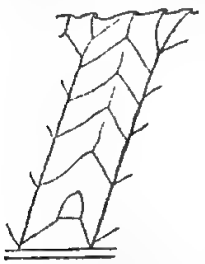


FIG. 40. *Campium bradfordi* Copeland, sp. nov.; type.

Ceylon, *Bradford*. Type in the herbarium of the University of California, No. 267415.

In venation, this differs from *C. subcrenatum* only in that, correlated with the rather more ample lamina, the lowest two veinlets are more likely to produce two excurrent veinlets, and these to unit and inclose an areola, but there may be only one excurrent veinlet in *C. bradfordi* or the two may run free; and in *C. subcrenatum*, less commonly, there may be two, and they may unite; or, rarely, there may be even three such veinlets; or, in both species, there may be two excurrent veinlets ("of the second order") from more than one pair of anastomosing veinlets.

43. CAMPIUM MOLLE Copeland, sp. nov. Plate 29.

Rhizomate valido basibusque stipitum paleis fuscis lanceolatis parvis vestitis; stipite frondis fertilis 80 cm alto, gracile sursum glabro, superne trisulcato; pinnis frondis sterilis utroque latere ca. 4, oblongo-lanceolatis, ca. 16 cm longis, 5 cm latis, acutis, basibus late rotundatis, integris, glabris, opacis, brunneis (in herbario), crassis, mollibus, stipitulis brevibus validis; venis primariis utroque facie inconspicuis, venulis more Goniopteridis areolarum seriem unam inter venas conficientibus cum liberis inclusis solitariis longis; foliola terminale paullo majore, crenato-undulata, nec attenuata nec prolifera; fronde fertile ca. 30 cm longa, 10 cm lata, pinnis utroque latere ca. 6, lanceolatis, 6–7 cm longis, 15 mm latis, acutis, basi truncato-cuneatis, dense fructiferis, areolas inter costam et marginem 5–7.

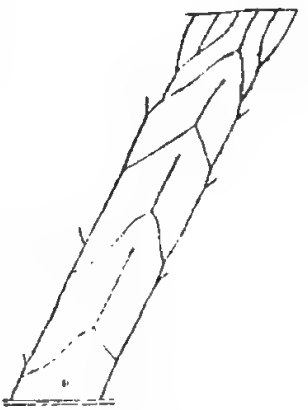


FIG. 41. *Campium molle* Copeland, sp. nov.; type.

Ceylon, *Gardiner*. Type in the Kew Herbarium.

This is the fern referred to by Hooker [32] under *Acrostichum virens* as "probably a distinct species." It differs from both *Campium costatum* and *C. subcrenatum* in texture, color, in-

[32] Spec. Fil. 5: 262.

conspicuous veins, acute but not at all caudate pinnæ, and absence of proliferation, and from the common forms of both, in the broad fertile pinnæ. The number, *1313*, cited by Hooker refers to "Ceylon Plants;" [33] but this is not at all the same as some of the material distributed under that number.

44. CAMPIUM SUBCRENATUM Presl.

Campium subcrenatum (Hooker and Greville) PRESL, Tent. Pterid. (1836) 239.

Acrostichum subcrenatum HOOKER, Hooker and Greville, Icones Fil. (1828) pl. 110.

Frondibus pinnatis, pinnis brevi-petiolatis subcrenatis lanceolatis acuminatis, sterilibus (septenis) basi cuneato-attenuatis, fertilibus (novenis) multo minoribus, basi, inferioribusque apice, obtusiusculis, rachi subalata. Hab. E. Zeylona, ubi in rupibus, prope Saffragan, provenit, communicavit *D. Emerson, M. D.*—HOOKER.

This was reduced to *Acrostichum virens* by its own author,[34] and Clarke [35] agreed that the two are hardly separable, even as varieties. To this, Beddome [36] made vigorous objection, charging Clarke with "not knowing subcrenata;" but the objection loses its force with Beddome's avowal that he did not himself know *A. virens*. Synonyms are *Poecilopteris terminans* Beddome and *Acrostichum proliferum* Hooker, non Blume, but not *A. contaminans* Wallich, nor *A. terminans* Wallich, nor *A. crispatulum* Wallich. As to the proper specific name, the older authors would have been practically unanimous in sacrificing *subcrenatum* for *virens;* but present usage is equally uniform, in treating Wallich's names as nomina nuda until somebody happened to publish a description or diagnosis with them.

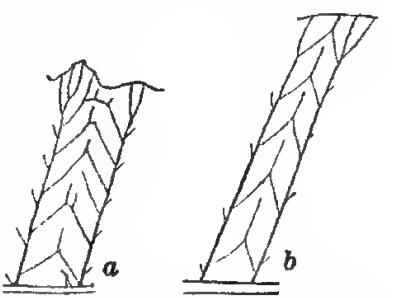


FIG. 42. *Campium subcrenatum* (Hooker and Greville) Presl; *a*, Cochin, *Gamble 14815 cult.; b*, southern India, *Gough 61.*

As Beddome has been the more modern protagonist of *Gymnopteris subcrenata,* I quote his description,[37] as follows:

Rhizome thick, fronds glabrous pinnate, 1–4 feet, of which the stipe is sometimes nearly half; stipes and rachis furnished with a few scales;

[33] See Thwaites, Enum. Pl. Zeyl. 380.
[34] Sp. Fil. 5: 261.
[35] Trans. Linn. Soc. Bot. 1: 581.
[36] Ferns of British India and Ceylon 439.
[37] Op. cit. 437.

sterile fronds, pinnæ 4–12 alternate or subopposite petiolate, broad lanceolate, sinuate or waved, with a longish serrated acumination, terminal pinnæ much the longest (sometimes 2 feet long), proliferous at the apex; primary veins close, costate and conspicuous nearly to the margin, veinlets anastomosing pretty regularly at right angles, from which proceed one or two generally free veinlets with clavate apices; fertile fronds conform to sterile, but much contracted.—BEDDOME.

As to the last point, it is to be observed that the fertile fronds of the original *Acrostichum subcrenatum* were not exceedingly contracted; I have here but one specimen, collected in Cochin by Lawson, with fronds as broad as the figure. Also, the original figure does not show an elongate apical leaflet; in most specimens this is as developed as in *Campium heteroclitum*. It is noted with misgivings that the venation of the fertile frond conforms with Presl's figure of *Campium costatum*, very perfectly. The range of venation of the sterile frond is shown in the accompanying drawings.

The sure geographical range is peninsular and northern India.

45. CAMPIUM FÉEIANUM Copeland, nom. nov.

Heteroneuron preslianum FÉE, Acrost. (1845) 92, pl. 39, f. 1, as to the description and figure.

Frondibus pinnatis, glabris, frondulis remotis, suboppositis, breve petiolatis, rhachi in parte frondulifera alato; sterilibus acutis, utrinque attenuatis, raro obtusis, subtus punctis atomariis, numerosis conspersis, frondulis superioribus saepe trilobati, infimis aliquando bilobis, lobo superiori brevi obtusissimo; fertilibus longious petiolatis, frondulis omnibus obtusissimis, basi acutis, terminali longiori; rhizomate crasso, repente, squamis angustis, attenuatis lanceolatis; sporangiis amplis, ellipticis, annulo 18 articulato, sporis episporio membraniceo.

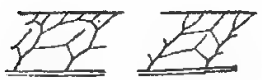


FIG. 43. *Campium féeianum* Copeland, nom. nov.; Concan, *Law s. n.*

Acristichum punctulatum Presl, Rel. Haenk., p. 16, nec Swartzii nec Willd.

Habitat in Philippinis, Sorsogon (Presl), in Asia (Hügel).—V. S.

Dimensions: Frondes stériles, 24–30 centim.; le pétiole est égal en longueur à la lame; largeur, 20–22 millim.—Frondes fertiles, 20–25 centim. de largeur; le pétiole est à la lame : : 1: 2; largeur, 7–8 millim.

Cette plante est fort distinct de toutes ses congenères. La nervation présente une maille à sommet anguleux, surmonté d'une droite; elle est formée par la rencontre de deux nervilles latérales. La nervation est donc connivente; elle devrait faire entrer cette plante dans le genre *soromanes*, si tout les autres caractères ne tendaient à en faire un *gymnopteris*. M. Presl, en écrivant *frondibus omnibus fructificantibus*, donne la preuve qu'il n'a connu que la fronde fertile de cette plante.—FÉE.

This is a rare fern of southern India.

SPECIES DUBIAE ORIENTALES

POECILOPTERIS STENOPHYLLA Kurz MS.; Teijsmann and Binnendyk in Nat. Tijdschr. Nederl. Ind. 27 (1864) 15.

P. frondibus pinnatis, pinnis sterilibus membranaceis, alternis, subopposititisve, breviter petiolatis, lincaribus, acuminatis, subintegris v. saepius obsolete crenatis, parallelo-venosis, reticulatis, glabris, subtus in costis stipiteque sparse paleatis; fertilibus angustioribus, crenatis, margine revolutis v. rarius planis.

Hab. in montibus prov. Bogor. 3–4000 p. s. m. e. q. in monte Salak.

Caudex repens, ramosus, viridis, brunnescente-paleaceus, radicosus. Frons sterilis, impari-pinnata, stipes ½–¾ ped. longus, obsolete tetragonus, viridis, supra canaliculatus, sparse (in juvenalibus dense-) secedente-paleaceus; pinnae alternae v. rarius subopposita, lineares v. linearilanceolatae, acuminatae, 4–5 poll. longae, 5–8 lin. latae, obsolete crenatae v. subintegrae, supra glabrae, obscure virides, nitentes, subtus in costis paleis brunnescentibus sparsis adspersae; frondis fertilis pinnae lineares v. lineari-lanceolatae, acuminatae, basi in stipitem attenuatae v. oblongo-lanceolatae, obtusae, margine crenato v. subintegro revolutae v. rarius planae, membranaceae, laete virides. Sori creberrimi, nigri, paginam inferiorem dense obtengentes.—TEIJSMANN AND BINNENDYK.

This seems to have been ignored by the Buitenzorg botanists, who should be able to identify the plant. As good a guess as I can make is that it is a nonradicant *Campium heteroclitum*.

CHRYSODIUM SAGENIOIDES Kuhn, Linnæa 36 (1869) 63.

Rhizoma deest; folia membranacea, opaco-viridia, infra in costis et rhachi paleis minutis squamulosa; sterilium lamina 1′ longa, ovata, pinnatisecta, apice pinnatifida; segmenta 7 juga, subsessilia, 7″ longa, 1¼″ lata, elongata, subpinnatifida, apice sinuata; nervi manifesti, primi in latere interno, reliqui catadromi, maculae Sageniae ad sinus loborum 4–5-seriatae, secus costulam 1-seriatae; fertilium lamina 1′ longa, segmenta distantia, petiolulata, ad 2½″ longa, 4‴ lata, e basi latiore elongata, sinuato-pinnatifida, apice integerrima, sorifera.

(*Acrostichum repandum* Hook. Spec. fil. v. p. 260 quoad plant. a Milne ex ins. Aneitens. reportat. t. fragm. aut.)

Aneitium, in silvis montanis (Herus n. 107. Feb. 1860. Milne.).—KUHN.

Much of this description would apply to the fern which I name *Campium samoense;* but it is hardly conceivable that a botanist as attentive to venation as Kuhn would impute the areolæ of *Sagenia* to that species, or any near relative of it. See remarks under *Campium palustre*.

Key to the African species of Campium.

1. Frond simple (or with few pinnæ below a large simple main portion).
   2. Base hastate or decurrent.

3. Free included veinlets wanting.
4. Sterile lamina lanceolate, 3 cm wide..... 54. *C. rawsoni.*
4. Lamina broader and larger..... 53. *C. fluviatile.*
3. Free included veinlets present..... 55. *C. gaboonense.*
2. Base cordate..... (56). *A. phanerodictyum.*

1. Pinnate, apex a leaflet like lateral ones.
2. Pinnæ linear..... 48. *C. salicinum.*
2. Pinnæ broad..... 51. *C. gemmiferum.*

1. Pinnate, apex of 2 to 4 fused pinnæ like others.
2. Pinnæ broadly lanceolate or broader.
3. Gemmiferous near base of terminal leaflet..... 51. *C. gemmiferum.*
3. Not gemmiferous in upper portion..... 52. *C. auriculatum.*
2. Pinnæ linear or linear-lanceolate.
3. Pinnæ entire..... 50. *C. heudelotii.*
3. Pinnæ toothed..... 49. *C. angustifolium.*

1. Pinnate, apex of many reduced pinnæ, or long-attenuate.
2. Sporangia congested on veinlets..... 46. *C. acrostichoides.*
2. Sporangia covering nether surface.
3. Lower pinnæ deeply cut..... 31. *C. bipinnatifidum.*
3. Lower pinnæ entire or nearly so.
4. Free pinnæ less than five..... 32. *C. boivini.*
4. Free pinnæ more numerous..... 47. *C. humblotii.*

46. CAMPIUM ACROSTICHOIDES (Afzelius) Copeland, comb. nov. Plate 30.

Hemionitis acrostichoides Afzelius apud Swartz in Schrad. Journ. (1801) 17.

Frondibus pinnatis distinctis, pinnis lato-lanceolatis, undulato-crenatis apice attenuatis; soris confluentibus. Afzelius.

Sierra Leone Africes.—Quoted from SWARTZ, Syn. Fil. 21.

According to Carruthers,[38] who named this plant *Acrostichum afzelii,* it is the African fern called *Acrostichum virens* in Species Filicum, and I have from the Gray Herbarium a Sierra Leone plant, *Scott Elliot 4048,* so determined at Kew.

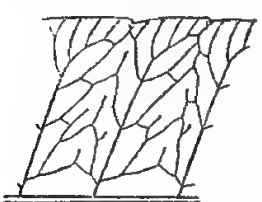


FIG. 44. *Campium acrostichoides* (Afzelius) Copeland, comb. nov.

It is a tall fern, the sterile lamina nearly 60 centimeters long, with many lateral pinnæ and a lobed, lashlike, terminal leaflet. It shares to some extent the characters of the groups of *Campium heteroclitum* and *C. quoyanum,* more nearly related to the former. In venation, it is strikingly like *C. subcordatum.* The sporangia are congested on the veinlets whence its original reference to *Hemionitis.* From the presence of five sheets from Liberia in the United States National Herbarium this seems to be a common species there.

[38] Cat. Welwitch Plants 2: 277.

47. CAMPIUM HUMBLOTII (Baker) Copeland, comb. nov.

Acrostichum humblotii BAKER, Journ. Bot. 22 (1884) 144.

Rootstock and fertile frond not seen. Sterile lamina oblong-deltoid, simply pinnate, 15–18 in. long, 8–9 in. broad, prolonged into a flagelliform rooting tip, moderately firm in texture, green and naked on both surfaces, the rachis also quite naked. Pinnæ 6–8-jugate, entire, lanceolate, acuminate, 1–1½ in. broad, the upper adnate and decurrent at the base, the lower free but sessile; several lower pairs subequal. Allied to *A. punctulatum* and *Blumeanum*.—BAKER.

Northeastern Madagascar, *Humblot 300*. From the same region, I have had from Kew a specimen collected by J. B. Last, in 1900. The sterile pinnæ are only about five on a side, up to 16 centimeters long, and only 2 centimeters broad, narrowed to both ends, and with the caudate tip denticulate. The more numerous, remote lateral pinnæ of the fertile frond are 4 to 5 centimeters long, about 6 millimeters broad, mostly stipitulate, and obtuse, the terminal one considerably longer.

FIG. 45. *Campium humblotii* (Baker) Copeland; Bé Kitsa Mountains, northeastern Madagascar, *J. B. Last*, 1900.

It is not very closely allied to *Campium auriculatum* (*punctulatum* of Baker) nor at all to his *Acrostichum blumeanum*, which is a *Lomagramma*. Like *Campium acrostichoides*, it has at least a common parentage with *Campium heteroclitum*. The veins are reddish by transmitted light.

48. CAMPIUM SALICINUM (Hooker) Copeland, comb. nov.

Acrostichum salicinum HOOKER, Spec. Fil. 5 (1864) 265.

Caudex creeping, stipites 4 inches to a span long stramineous (as are the rachis and costae), fronds firm-membranaceous dark-green 3–4 inches to a foot long ovate-oblong pinnated to the very apex, pinnae of the *sterile* frond 2–3–10, 1½–4 inches long rarely exceeding ½ an inch broad lanceolate sometimes long and finely acuminate or obtuse entire or subserrate cuneato-attenuate long-petiolate, costules obscure with few transverse connecting arched veins, these form about two series of large areoles next the costa irregularly anastomosing towards the margin, free included veins rare; *fertile* fronds rather smaller more obtuse and in one instance rather coarsely serrated.

FIG. 46. *Campium salicinum* (Hooker) Copeland, comb. nov.; cotype.

Hab. Niger Exped., Sierra Leone, *Barter*, Fernando Po, *G. Mann*, *n.* 1339.

This very distinct pinnated species has the appearance of having grown in wet places. A sterile frond with alternate, long, narrow-lanceolate, long-petiolate pinnae, with their pale-coloured costae, has very much the appearance of *Salix amygdalina* or some allied species of Osier. Quite different from *A. Heudelotii*, besides other characters, in the entirely pinnated frond, the terminal pinna long-petioled.—HOOKER.

As a mere name, Bonaparte has listed from the Belgian Congo a variety *latipinna*. A sterile cotype in the Gray Herbarium has all pinnæ acuminate, a few of the broadest ones with obliquely crenate margin, and a small bud well below the apex of the terminal leaflet.

Where originally published, the description of this species follows that of *Acrostichum preslianum* (*Campium féeianum* of this presentation); each of these is more nearly related to the other than to any other known species.

49. CAMPIUM ANGUSTIFOLIUM Copeland, sp. nov. Plate 31.

Campium C. heudelotii affinis: rhizomate 5 mm crasso, late repente, paleis atrocastaneis lineari-lanceolatis 4 mm longis persistentibus obtecto; stipitibus remotis, ca. 25 cm longis, fuscis, sursum rhachibusque paleis persparsis praeditis; fronde sterile 30 cm longa, ovata, pinnata; pinnis utroque latere ca. 10, infimis stipitulatis basi subsymmetrice cuneatis, superioribus adnatis, supremis paucis paullo reductis coalescentibus, plerisque ca. 12 cm longis, 1 cm latis, acuminatis, remote et obtuse serratis, herbaceis, opacis, glabris, costa tenue inter venas primarias venulam emittente, venis obliquis, infra marginem dissipatis; areolis primariis paucis, cum venulis inclusis tenuissimis aut liberis et saepe ramosis aut iterum anastomosantibus; fronde fertile conforme paullo minore, pinnis 5–7 cm longis, 6 mm latis, obtusis.

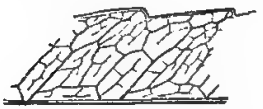


FIG. 47. *Campium angustifolium* Copeland, sp. nov.; type.

Cameroons, Buar, altitude 1,000 m. s. m., on stones in a brook, *Milbraed 9404*. Type in the Kew Herbarium. Also Sanaga, *Zenker 1467*, in the herbarium of the Missouri Botanical Garden, No. 122176.

This differs from *Campium heudelotii* in having narrower and serrate sterile pinnæ and obtuse fertile pinnæ, and apparently in the details of the venation. The apex of the frond is like that of *Campium heudelotii* and unlike that of *C. salicinum*.

50. CAMPIUM HEUDELOTII (Bory) Copeland, comb. nov.

Gymnopteris heudelotii BORY in Fée, Acrost. (1845) 84, pl. 45.

Frondibus pinnatis, glabris, frondulis sterilium lanceolato-linearibus, acuminatis, sessilibus, margine repandis, basi exteriore decurrentibus, ultimis irregulariter connatis pinnatifidisque, petiolis et rhachi caniliculato-striatis, nervillis secundariis et tertiariis rubro-translucentibus, ultimis opacis; fertilibus linearibus, alternis, sessilibus, ultimis pinnatifidis; sporangiis fuscis, magnis, annulo leviter crenato, 13 articulato, sporis ovoideis, episporio caduco,—Planta sicca virescens.

Habitat in aquis vivis Foula Dhiallon in Senegambia (Heudelot).—V. S. in herb. Bory.

Dimensions: Frondes stériles, longueur, 30 centim.; les plus grandes frondules, 20-25 centim.; largeur des lames, 22–25 millim.; des entrenoeuds, mesurés vers les premières paires de frondules, 3 centim.=Frondes fertiles longueur, 34 centim.; les plus longues frondules, 15 centim.; largeur, 1 centim.; distance entre les premières frondules au second entrenoeud, 5 centim.—Fée.

Probably common in the Congo region; Bonaparte [39] cites nine collections.

The coadunate apex is formed as in *Campium auriculatum*, by the fusion of the bases of a very few pinnæ which are directed almost upward, indicating no affinity to the group of *Campium quoyanum*. The venation is figured by Fée as similar to that shown herewith for *Campium angustifolium*, but apparently with less extreme development of free included veinlets, especially along the costa.

51. CAMPIUM GEMMIFERUM (Hieronymus) Copeland, comb. nov.

Leptochilus gemmifer Hieronymus, Engler's Bot. Jahrb. 46 (1911) 345.

L. ex affinitate *L. auriculati* (Lam.) C. Chr.

Rhizoma repens, usque ad 6 mm crassum, juventute dense paleaceum; paleis nigro-fuscescentibus, e basi cordata (auriculis introrsum arcuatis imbricatis) deltoideo-ovatis, acutissimis, margine parce ciliatis (ciliis articulatis saepe apice cellula incrassata glandulosa terminatis vix ultra ½ mm longis), basi cellulis parenchymaticis parte superiore breviter prosenchymaticis parietes internos nigro-fuscescentes c. usque ad 0.015 mm crassos et externos tenues hyalinos vel lutescenti-pellucidos gerentibus numerosis formatis; paleis maximis c. 3¼ mm longis, 1 mm supra basin latis. Folia sterilia c. 3–5 (ex schedula –7½) dm longa, longe petiolata; petiolis supra trisulcatis, infra teretibus, olivaceo- vel griseo-fuscescentibus medio c. usque ad 1¾ mm crassis, basi crassioribus usque ad 3 mm crassis, praesertim parte inferiore sparse peleaceis (paleis iis rhizomatum similibus, minoribus); laminis pinnatis, infra pinnam imparem terminalem plerumque gemmiferis; pinnis glabris, membranaceis; lateralibus utroque latere 6–10 subsessilibus vel (inferioribus) breviter petiolulatis (petiolulis vix ultra 3 mm longis), e basi superiore rotundato-cuneata et inferiore cuneata sive exciso-cuneata oblongis, acutis vel acuminatis, margine subintegris vel undulato-crenatis vel undulato-lobulatis, plerumque alternis raro (inferioribus) suboppositis; intervallis in laminis maximis usque ad 2½ cm longis; costis utrinque prominentibus teretibus glabris; nervis lateralibus primariis angulo antico c. 60° a costa arcuatim ascendentibus marginem non attingentibus, nervis secundariis vel venis reticulatim anastomosantibus, inter nervos laterales primarios areolarum series 3–4 formantibus, utrinque parum prominulis; pinnis maximis foliorum sterilium maximorum c. 13 cm longis, 2½ cm latis.

[39] Notes Ptérid. 14 (1923) 218, 256.

Folia fertilia longitudine folia sterilia aequantia, interdum paulo longius petiolata, pinnis lateralibus pro conditione minoribus utrinque 5–7 cum impari terminali, obtusiusculis vel acutiusculis. Sporangia superficiem inferiorem ubique obtegentia, c. 0.22 longa, 0.2 mm lata, stipitata (stipite c. 0.4 mm longo). Sporae bilaterales, ubique cristis reticulatim conjunctis c. 0.01 mm altis lutescenti-pellucidis ornatae, fuscescentes, c. 0.5 mm cristis inclusis longae, 0.4 mm latae.

Angola: im Gebiet von Golungo Alto (Welwitsch n. 157b mit dem Manuscriptnamen *Acrostichum* (*Chrysobotrya*) *angolense* Welw.).—HIERONYMUS.

There follow citations of specimens showing the species to be common in German East Africa. Also, description of a var. *latipinnata*, with larger pinnæ, farther apart, with broader base, cited from the Congo and Kamerun.[40] This variety is *Leptochilus acrostichoide* var. *cuneata* R. Bonaparte, Notes Ptérid. 15 (1924) 19.

The species and variety are described as distinguished from *Campium auriculatum* by the usually more numerous, stalked pinnæ, the terminal leaflet not usually fused with the next below, and with a bud at or above the base of the terminal leaflet.

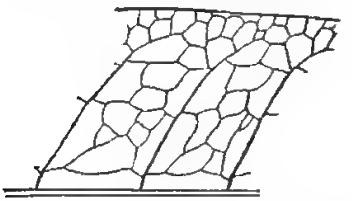


FIG. 48. *Campium gemmiferum* (Hieronymus) Copeland, comb. nov.; Niger, *I. Barter*.

The specimen from which I have drawn the venation was probably collected along the Niger, by Barter (the doubt is due to the mounting of two collections on one sheet), and conforms with the description in all observable characters, including all mentioned as distinctive. There is hardly another instance in the genus of two species so alike in venation as this and *Campium auriculatum*.

52. CAMPIUM AURICULATUM (Lamarck) Copeland, comb. nov.

Acrostichum auriculatum LAMARCK, Encycl. 1 (1783) 36.

Acrostichum punctatum Lin. f. Suppl. 444.

Cette plante a ses feuilles aîlées, composées de folioles lancéolées, très-entières, aeterne, glabres & ponctuées en-dessus. Les folioles inférieures sont auriculées, & les supérieures sont confluentes. D'ailleurs, selon M. Linné, cette plante ressemble beaucoup à celle qui précède: on la trouve dans l'Île de Bourbon.—LAMARCK.

Acrostichum fronde pinnata: foliolis alternis lanceolatis integerrimis: infimis auriculatis, supremis decurrentibus, supra punctatis glabris.

Habitat in Isle de Bourbon. *Sonnerat per Thouin.*—LINNÆUS f.

[40] A fertile frond of the variety, in the herbarium of the Missouri Botanical Garden, *Zenker 4120*, from Kamerun, has nine or ten pinnæ on each side, mostly about 6 centimeters long by 15 to 20 millimetérs wide, the whole frond 45 centimeters long.

Apparently common throughout equatorial Africa, and quite constant in the peculiar form of the frond. The scaly rhizome is creeping, with the fronds rather remote. The upmost two pinnæ, otherwise like the others and but little smaller, are fused at the base; those below them are adnate at least on the lower side; and the basal pair, commonly the only stipitulate ones, bear each a prong on the lower side, as is common in *Tectaria*. Because of this and some minor resemblances to *Pleocnemia*, I was for some time indisposed to transfer the bulk of the African species to *Campium*, suspecting a phylogenetic line related and parallel to *Hemigramma;* but the study of *C. acrostichoides*, especially, has convinced me that while, like the Indian species, they constitute a group coherent within itself, they belong collectively in the same genus as *C. heteroclitum*. A Uganda plant doubtfully referred here, *Drummer 4011*, has very large crenate-sinuate pinnæ.

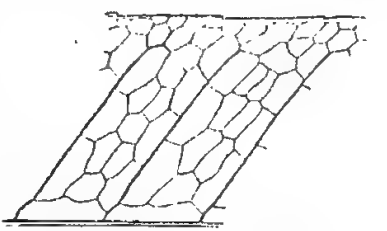


FIG. 49. *Campium auriculatum* (Lamarck) Copeland, comb. nov.; Mauritius.

The specific segregation of *Campium gemmiferum* makes necessary a rechecking of all old specimens, before their respective ranges can be known. Bonaparte[41] cites eighteen collections of *C. auriculatum* and six of *C. gemmiferum*.

53. CAMPIUM FLUVIATILE (Hooker) Copeland, comb. nov. Plate 32.

Acrostichum fluviatile HOOKER, Spec. Fil. 5 (1864) 274.

Caudex long creeping branched, stipites stout a foot or more long, 2 feet of the sterile frond; *sterile* fronds 1½–2 feet long firm-membranaceous simple broad-lanceolate and entire, or larger and hastato-trilobate, with lateral segments 6–7 inches long 2½ inches broad ovato-oblong acuminate horizontal, middle lobe 16 inches long 4 inches wide broad-lanceolate or larger still and pinnatifid with about 5–9 large segments, inferior lateral ones and the terminal one as in the second form just described, costae rather stout, costules indistinct, veins everywhere distinct regularly anastomosing into rather large uniform hexagonal areoles rather smaller towards the margin quite destitute of any free included veinlets; *fertile* fronds similar to the sterile ones hastate or pinnatifid but much smaller.

Hab. Fernando Po, on the banks of a river, *Gustav Mann, n.* 442,–Niger Expedition, *Barter*. West tropical Africa, Curror . . . .—HOOKER.

The Fernando Po specimen in the Gray Herbarium, presumably a cotype, has short, merely acute barbs at the base of a large simple frond, the main part of which is acuminate. The

[41] Notes Pterid. 14 (1923) 254.

frond has the deep green color common in species growing in very wet places. The young part of the rhizome is densely covered with long, linear, dark fuscous paleæ, which are also sparsely present on young stipes.

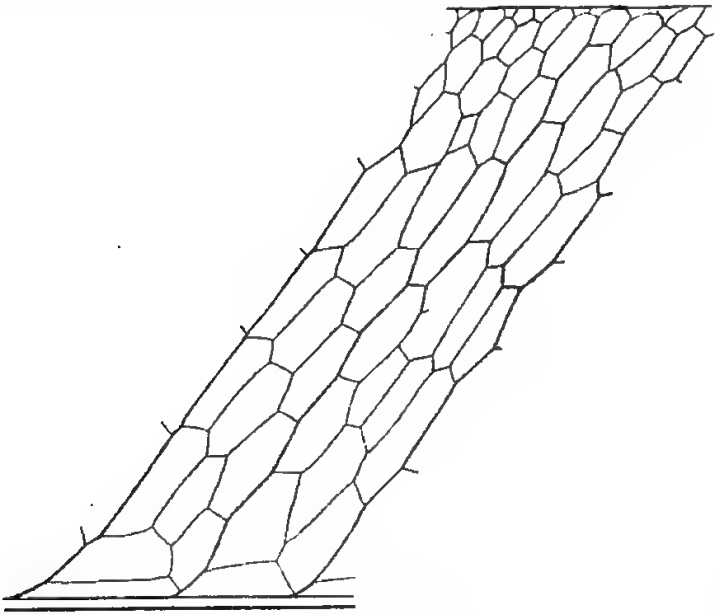


FIG. 50. *Campium fluviatile* (Hooker) Copeland, comb. nov.; cotype with short-hastate frond, Fernando Po.

Such a fern might have been evolved directly from the *Dendroglossa* section; but I think it much more probable that this species is derived, by consolidation of the frond, from pinnate ancestors. A step toward it, in venation as well as in fusion, is represented by *Campium auriculatum*. Specimens from S. Thomé, *Quintas 58*, United States National Herbarium, No. 51084, are a juvenile form of this or a distinct species. The lanceolate, caudate fronds are at most 15 centimeters long, and the stipes are very slender.

54. CAMPIUM RAWSONI (Baker) Copeland, comb. nov.

Acrostichum rawsoni BAKER, Ann. Bot. 5 (1891) 496.

Rootstock erect; basal paleae small, dense, linear, dark brown, crisped. Stipe of sterile frond 6–7 in. long, fragile, naked, pale brown. Sterile frond simple, lanceolate, membranous, glabrous, 6–8 in. long, 1–1½ in. broad, rounded to a cuneate base. Areolae copious, without free included veinlets. Stipe of fertile frond ½ ft. long; blade linear, 6–7 in. long, ½–¾ in. broad, with enrolled edges. Grand River, Mauritius, *Sir Rawson Rawson*, gathered in 1853. Habit of *A. lanceolatum*; veining different.—BAKER.

55. CAMPIUM GABOONENSE (Hooker) Copeland, comb. nov.

Acrostichum gaboonense HOOKER, Spec. Fil. 5 (1864) 270.

Caudex creeping sparingly paleaceous with dirty-brown small subulate scales, stipites numerous approximate 6–7 inches long sparingly paleaceous at the base, of the fertile fronds twice or thrice as long, fronds simple; *sterile* ones firm-membranaceous 12–14 inches long 3–3½ inches broad ovato-lanceolate acuminate and proliferous at the apex moderately attenuated at the base entire or sinuate at the margin dark blackish-green, costa prominent beneath, venation very distinct, costules horizontal wide apart connected by many transverse curved veins forming a series of long narrow costal areoles free from veins or slightly veinleted, the rest forming several wide arched areoles filled with a network of irregular areoles with or without an included veinlet, veining near the margin free; *fertile* frond 4–6 inches long 1–1½ inch wide lanceolate subentire or sinuato-pinnatifid.

Hab. Gaboon River, west tropical Africa, lat. 1° N., *Gustav Mann.*—HOOKER.

Since reported from various places in west tropical Africa, but apparently not very common. It looks like a large relative of *Campium decurrens*, with less abundant free included veinlets. Broad fronds have six or more major areolæ between costa and margin instead of the three or four shown by the accompanying drawing.

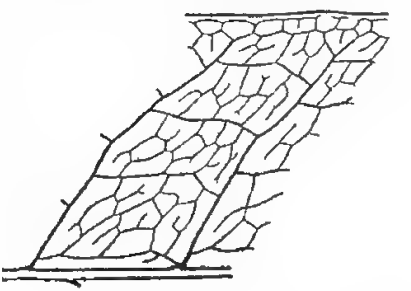


FIG. 51. *Campium gaboonense* (Hooker) Copeland, comb. nov.; *Zenker 3806.*

The specimen in the herbarium of the Missouri Botanical Garden, No. 122190, *Zenker 3806* from Kamerun, has one imperfectly fertile frond, on which the sporangia are borne first on the minor veinlets, and spread to the "parenchyma" only near the margin. The angle at which the main veins leave the costa may be 90°, or may be more acute than as drawn. Kamerun specimens in the United States National Herbarium, *Zenker 3806*, have sterile fronds up to 45 centimeters and the fertile 30 centimeters long.

56. ACROSTICHUM PHANERODICTYUM Baker.

I have been unable to secure a diagnosis of this species or to learn more than that it has long, simple, cordate sterile fronds. It was described from St. Thomas Island, which lies off the west coast of Africa.

In the same group of species, Engler,[42] mentions a *Gymnopteris preusii* Hieronymus, which is reduced by Christensen to his *Leptochilus rivularis;* it seems to be a nomen nudum.

Leptochilus diversifolius and *L. grossedentatus,* named and imperfectly described in French by Bonaparte,[43] are likewise not validated. The former seems to be a small form or relative of *Campium rivulare,* and the latter is multipinnate. The same author [44] lists *Leptochilus currori,* concerning which I know nothing—unless it be that there is a species of *Lonchitis* having that name. Finally, the Index Filicum cites *Acrostichum labrusca* Christ, Ann. Mus. Congo 5 I (1903) 10, but I cannot find it there.

Genus HEMIGRAMMA Christ

The genus *Hemigramma* was established by Christ,[45] for the single species that he called *H. zollingeri,* for the best reason that can motivate the establishment of a new genus for a species long known; namely, the recognition of a source in phylogeny manifestly different from that of the genus from which the species is removed. Christ recognized this species as distinctively tectarid. As I showed soon afterward,[46] this origin is unusually clear, quite as clear as that of *Campium linnaeanum,* shown in the preceding pages. *Hemigramma* is, then:

A genus of tectarid ferns, as shown by the short, stout, erect or ascending, scaly rhizome, scaly stipe, deltoid form of all except simple fronds, and sagenioid venation, distinguished from *Tectaria* by the marked dimorphism and the spread of the naked sori, whether only all along the veins, as in *Hemionitis,* or eventually over the entire nether surface.

A few years after the genus was established, I described a second, apparently well-distinguished, larger species, from Papua. A third, from Mindoro, was resently found for the second time, nearly a century after its discovery; and in looking up the various ferns that are listed as species of *Leptochilus,* I find still others which quite certainly belong here. In every case, this is shown by a combination of the characters of rhizome, stipe, frond form, and venation.

[42] Pflanzenwelt Afrikas 2 (1908) 16.
[43] Notes Ptérid. 14 (1923) 216, 217.
[44] Op. cit. 215.
[45] Philip. Journ. Sci. § C 2 (1907) 170.
[46] Philip. Journ. Sci. § C 3 (1908) 31, pls. 1–4.

Key to the species of Hemigramma.

1. Simple, or pinnate with rachis mostly winged.
   2. Stipe of sterile frond short..... 1. *H. latifolia.*
   2. Stipe 25 cm or more long.
      3. Basal lobes or pinnæ simple.
         4. Fronds trifid..... 2. *H. decurrens.*
         4. Fronds trifoliolate ..... 3. *G. bonii.*
      3. Basal pinnæ forked.
         4. Sterile segments or pinnæ lanceolate..... 4. *H. hollrungii.*
         4. Sterile divisions broader ..... 5. *H. taccifolia.*
1. Pinnate, rachis mostly wingless.
   2. Apical segment trifid..... 6. *H. grandifolia.*
   2. Apical segment simple ..... 7. *H. siifolia.*

1. HEMIGRAMMA LATIFOLIA Copeland.

Hemigramma latifolia (Meyen: Goldmann) COPELAND, Philip. Journ. Sci. § C 2 (1907) 406.

Polybotrya latifolia Meyen in herb., teste Presl.

Gymnopteris latifolia PRESL, Tent. Pterid. 244, nomen; GOLDMANN, Nova Acta 19 Suppl. 1 (1843) 460.

Frondis simplicis pinnis coriaceis oblongis margine irregulariter crenatis acuminatis uno latere basis decurrentibus, venis subpinnatis, venulis binis primariis cum venis trapezoideas aut hexagonoideas figuras formantibus, venulis secundariis, tertiariisque in diverse formae figuras concurrentibus et in apice globoso desinentibus, pinnis fertilibus contractis, soris paginam inferiorem totam tegentibus. Manila.—GOLDMANN.

Presl's [47] much better description fixes the type locality definitely at "Hali-Hali," properly Jalajala, Rizal Province, Luzon.

This may well be the least stable of all the species of ferns. It has the distinction of appearing in Christensen's Index under two widely separated genera, and has been referred by various authors to a long list of others. This is due to variability in the distribution of the sporangia, and it owes a wealth of specific names to its variability in other respects.

The rhizome is more or less erect, short, stout, densely covered by scales, roots, and bases of stipes; the stipes are likewise quite densely and persistently scaly. The commonest form has very short stipes, from a few millimeters to 2 or 3 centimeters in length, the fronds forming a dense rosette. With simple, entire fronds, it is typical *Polybotrya latifolia* Meyen, *Hemionitis zollingeri* Kurz, and *Leptochilus hilocarpus* Fée. Such fronds may be less than 10 centimeters long on plants already in fruit. Somewhat larger plants, with a large lobe on (one

[47] Epimeliae 150.

,or) both sides at the base, are *Gymnopteris trilobata* J. Smith: Mettenius. With still larger fronds, commonly 15 to 25 centimeters long, and two or three pairs of lobes, it is *Gymnopteris subquinquefida* J. Smith, *Leptochilus*, Fée; and there is nothing in the description of *Leptochilus trifidus* v. A. v. Rosenburgh, Bull. Dept. Agr. Ind. Nierl. 18 (1908) 26, to create the suspicion that it is at all different. These forms are not merely connected by intermediates; they very generally occur together, and, once a plant outgrows the exclusively simple stage, it usually bears a variety of fronds, different enough to characterize good species if they were constant. Nor does this exhaust the forms; it is not at all rare for the basal lobes to become separate pinnæ. It is rare, but does occur, that these basal pinnæ are forked at the base on the lower side. Plants with large fronds usually bear fewer of them, and the rosette character disappears. The base of the frond may be decurrent, or acute, or abrupt, or cordate, or be abruptly contracted to a short, broad wing, itself abrupt at the bottom.

The fertile frond is longer-stalked, as is practically universal among ferns with dimorphous fronds. It may conform in division with the sterile fronds of the same plant, or may be more nearly simple. It is usually narrowly linear, but not filiform; dilated fronds, which I construe as atavastic, are not rare. The sporangia are at first confined to the veins, but may finally extend to the parenchyma.

It may be observed that I retain *Campium minus* with the status of a species, but do not similarly distinguish the dwarf forms of *Hemigramma latifolia*, likewise fertile, and often collected by themselves. This is done on the basis of field familiarity with both in the Philippines. Only cultural study will finally determine which course is proper in either case.

Common in the Philippines; known in various other parts of Malaya.

2. HEMIGRAMMA DECURRENS (Hooker) Copeland, comb. nov.

Gymnopteris decurrens HOOKER, Journ. Bot. 9 (1857) 359; Exotic Ferns, pl. 94.

Gymnopteris harlandi HOOKER, Garden Ferns, pl. 6; *Leptochilus harlandi* C. Christensen.

Fronde sterili ampla submembranacea nitida pinnata, pinnis subquinque ovali-lanceolatis longe tenui-acuminatis obscure sinuatis basi decurrentibus tribus superioribus coadunatis terminali maxima, fertilimulto minore rigidiore, pinnis angustioribus vix acuminatis repando-sinuatis, stipite elongato rachibusque castaneis nitidissimis.

Hab. Hongkong, *Dr. Harland.*—HOOKER, Journ. Bot. 9 (1857) 359.

This seems to be larger than any other species of its genus; sterile frond 45 centimeters long, beside a tall stipe, and 35 centimeters wide. As in other species, the rhizome is stout and the fronds are crowded. See further comment under *Gymnopteris bonii*, infra.

3. GYMNOPTERIS BONII Christ.

Gymnopteris bonii CHRIST, Bull. Herb. Boiss. II 4 (1904) 610.

Magna. Rhizomate brevi obliquo ascendente digiti crassitie, lignoso. Stipitibus subfasciculatis (3 vel 4). Stipite tenui ad basin incrassato rufobrunneo, squamis nitidis subulatis 1 cm. longis dense vestito. Folii sterilis stipite 25 cm. longo, folii fertilis stipite 40 ad 45 cm. longo.

Fronde sterili deltoideo-pinnata 25 ad 30 cm. longa 20 cm. lata, pinna terminali ampla triloba (interdum biloba aut integra) ovato-acuminata 20 ad 25 cm. longa, lobo terminali 15 cm. longo 8 cm. lato cum lobis lateralibus aliquantum minoribus ad basin late, saepe oblique connato decurrenti, a pinnis lateralibus spatio 5 cm. metiente separato. Pinnis duabus lateralibus paribus (una utroque racheos latere), ovatis, rarius decurrentibus. Pinnis et lobis integris aut leviter undulatis. Costis rufescentibus. Nervis lateralibus fere usque ad marginem conspicuis, 7 mm. inter sese distantibus, areolis magnis nervulis multis ramosis liberis clavatis repletis.

Fronde fertili conformi, sed valde reducta, 10 cm. longa, lobis pinnisque 7 cm. longis 1 cm. latis lanceolato-linearibus acutis crenato-repandis, facie inferiori sporangiis confertis brunneis omnino repleta, vix costa emergente.

Textura herbacea, facie glabra, colore brunneo-viridi. Ad *G. Harlandi* (Hook. Acrostich.) Chinae meridionalis (Hong-Kong C. Faber) accedens, quae multo minor, valde coriacea.

Hab. Tonkin Gall. Ninh-Thoi C. P. Bon, 22. XII. 1888, N° 4070, 5410. Formosa in rupestribus littoris Kelung C. Faurie, mai. 612.—CHRIST.

There is no question that this belongs in *Hemigramma*, and in most genera it would hardly occur to me to doubt its specific distinctness. In *Hemigramma*, I have enough doubt not to care to transfer the name. I have from the Gray Herbarium a specimen of *Hemigramma decurrens* from Formosa, collector and date not stated, but distributed from Kew. It is moderately, but not "valde," coriaceous and, unlike the Hong Kong plant as described (in English) and figured, has the ribs of the sterile frond absolutely glabrous beneath. In form and stature it conforms perfectly to Hooker's specifications.

Leptochilus kanashiroi Hayata, Icones Fl. Form. 5 (1915) 298, is described as distinguishable from *L. bonii* "by the much broader pinnæ of the fertile fronds." The frond may be trifoliolate or merely trifid, and the segment may be entire or irregularly crenate-lobed. Such differences are far within the range of forms familiar in *H. latifolius*, and might be expected in its relatives. A Kuangtung specimen, *Levine 748*, has the

fertile pinnæ nearly as wide as Hayata describes, and simple and trifoliolate fronds on the same plant. The rhizome and the scales on it and on the bases of the otherwise naked stipes are characteristic of the genus. It is papyraceous, not coriaceous.

4. HEMIGRAMMA HOLLRUNGII (Kuhn) Copeland, comb. nov.

Gymnopteris hollrungii KUHN, in Schumann and Hollrung, Fl. Kaiser-Wilhelmsland (1889) 8.

I have not seen the original diagnosis of this, but quote from van Alderwerelt, Malayan Ferns, page 737:

Rhizome erect, densely clothed with ferrugineous, long-acuminate bristle-like scales. Stipes scaly at the base, 40–50 cm. long, canaliculate. Sterile fronds 25–30 cm. long, 35–40 cm. broad, with the base pedatisect, the higher part pinnatifid; lobes lanceolate, 25–30 cm. long, 3–4 cm. broad, entire, acuminate. Texture subcoriaceous, surfaces naked. Fertile fronds 25–30 cm. long, 30–40 cm. broad, pinnatifid, on stipes 60–65 cm. long; lobes 15–20 cm. long, linear, entire or slightly sinuato-repand.

New Guinea and New Pomerania.

5. HEMIGRAMMA TACCIFOLIA (J. Smith: Fée) Copeland, comb. nov.

Gymnopteris taccaefolia J. SMITH, Hooker's Journ. Bot. 3 (1841) 403, nomen.

Leptochilus taccifolius FÉE, Acrost. (1845) 89, pl. 50.

Frondibus sterilibus amplis, pinnatifidis, segmentis infimis bipartitis, lateralibus ovato-lanceolatis, acuminatis, glabris, repandis, inferne subpetiolatis, superne basi confluentibus, rhachi alato, impari tripartita, nervillis prominentibus, reticulato-flexuosis, rufescentibus; fertilibus pinnatifidis, anguste linearibus, oppositis, segmentis infimis bifidis, apice acuminatis, stipitibus in omnibus glabris, striatis, depressis; rhizomate crasso; sporangiis annulo lato, 11–12 articulato, sporis ovoideis, episporio inaequale membranaceo.

Dimensions: Longueur de la fronde stérile, 43 centim.; pétiole, 7 centim.; frondules de la base, 22 centim., sur 5–6 de large; elles ouvrent avec la nervure médiane un angle de 65° environ. Longueur de la fronde fertile, 42 cent.; partie fructifère, 18 centim.; segments inférieurs, 12–14 centim.—FÉE.

MINDORO, *Cuming 357*, Puerto Galera, Bur. Sci. *46428 Ramos*, 1925.

From the Cuming collection, Presl, too, described this fully as to the laminæ, but without trying to state the length of the stipe of the sterile frond. As to the Ramos collection:

Stipe of the sterile frond 20 to 35 centimeters long, of the fertile frond, up to 50 centimeters. Sterile frond 25 to 35 centimeters long, and not quite as wide, pinnate, or sometimes with the rachis winged to the base. Free pinnæ usually one pair,

opposite, adnate or not, deeply cleft near the base on the lower side; above these, about three pairs of oblanceolate, acuminate lobes of which the lower are sometimes free (pinnæ), and a larger apical segment. Fertile frond about as large, its pinnæ up to 25 or 30 centimeters long, one or two pairs of them deeply split into two long, linear or filiform divisions. Following Hooker, and well knowing *Hemigramma latifolia* to be extremely variable, I supposed this to be merely its most ample form. Having this idea, when the real *H. taccifolia* came recently into my hands, I prepared for it a diagnosis as a new species; however, it is very exactly, and completely enough, described by Presl. At least as to the specimens in hand, it differs from *Hemigramma latifolia* in color, being a light, brownish green, whereas the latter is characteristically either quite dark, or mre often mottled.

6. HEMIGRAMMA GRANDIFOLIA Copeland.

Hemigramma grandifolia COPELAND, Philip. Journ. Sci. § C 6 (1911) 77.

Fronde pinnata ca. 30 cm alta et lata, longe stipitata; pinnis oppositis utroque latere 2 vel 3; pinnis sterilibus vel segmentis earum oblonceolatis, acuminatis; infimis 1 vel 2 furcatis, apicale trifida, frondis fertilis pinnis infimis usque ad 15 cm longis, 2 mm latis, simplicibus, sporangiis laminam obtegentibus.

No. 328, Lakekamu.

A very distinct species, the sterile frond preserving in large measure the form of *Tectaria crenata*, from which, or from near which I consider the genus to be descended.—COPELAND.

Known only in New Guinea and only from the one collection.

7. HEMIGRAMMA SIIFOLIA (Rosenstock) Copeland, comb. nov.

Leptochilus siifolius ROSENSTOCK, Med. Rijks Herb. Leiden 14 (1912) 32.

Adest folium unicum sterile et unicum fertile.—Folium sterile (stipite incl.) 32 cm longum, 27 cm latum; stipes 2 mm fere crassus, ochraceo-stramineus, basi fuscescenti paleis parvis, lanceolatis, fuscis sparse ornatus, sursum cum rhachi brevissime tomentosus; lamina e basi cordato-truncata rotundato-deltoidea, membranaceo-herbacea, in sicco lutescenti-viridis, costis supra brevissime tomentosis exceptis glaberrima, pinnata; pinnae oppositae, trijugae cum impari terminali, obovato-oblongae, breviter acuminatae, margine integerrimae, basales recte patentes, profunde furcatae, ramo posteriore quam anterior paulo minore, ceterae suberectae simplices, inferiores et mediales breviter petiolatae, superiores subsessiles, terminalis petiolo 1 cm fere longo instructa; pinnae omnes inter se fere subaequales, terminalis maxima, 16 cm longa, 3½ cm lata; costae subtus prominentes, supra prominulae; venae primariae conspicuae, strictae, sub angulo 60° ex costa excurrentes, marginem fere attingentes, secundariae et tertiariae

more *Sageniarum* dense reticulatae, maculis venis liberis creberimis instructis; folium fertile stipite 35 cm. longo instructum, lamina sterili subaequalis et ambitu conformis, attamen pinnae anguste lineares et circinnato-flexuosae.

Lombok SW., Sepi-berg, Nordabhang, 0–300 m. (C. Gründler no. 2485).

Diese Art unterscheidet sich von dem nächst verwandten *Leptochilus latifolius* Meyen von den Philippinen besonders durch die Gestalt der sterilen Blätter. Während diese bei genannten Art entweder durchaus oder doch in ihrem oberen Theil fiederschnittig sind, besitzt unsre Art echt gefiederte Blätter mit gestielten und nicht herablaufenden Fiedern. Sie gleichen denen des *Aspidium siifolium* Willd., sowohl in der gestalt, als auch in der Nervatur.—ROSENSTOCK.

Excepting of *Hemigramma latifolia*, past collections are not sufficient for the satisfactory characterization or delimitation of the species of *Hemigramma*. I do not try to decide that seven species, or only seven valid species, are known to date. *Hemigramma latifolia* is quite certainly distinct from any other species listed here; and its listed synonyms are positively such, with the possible exception of *H. zollingeri*. As to the latter, while nothing of the kind can be deduced from its description, better acquaintance may show that it is locally evolved, independently of the simple form of *H. latifolia*.

Hemigramma decurrens, *Gymnopteris bonii*, and *Leptochilus kanashiroi* are not well enough known to establish their constant differences, or their identity. Plants conforming to their respective descriptions have concurrent distribution, and there has not been sufficient collection to demonstrate that any one of them is constant, or variable, in character. It should be emphasized that the fact that *H. latifolia* is exceedingly variable is no conclusive argument against the constancy of a related species. *H. taccifolia* appears to be local and clear-cut.

These remarks as to the far-northern species apply equally to the three large species of the southern area, *H. hollrungii*, *H. grandifolia*, and *H. siifolia*. If they conform to the published descriptions, they are distinct; but single collections provide inadequate evidence that they do this.

Genus QUERCIFILIX Copeland, novum

Genus tantum monotypicum filicum verosimiliter e Sagenia evolutarum; rhizomate ad terram repente; frondibus parvis approximatis, pinnatis, dimorphis, pilosis; venulis anastomosantibus cum liberis ramosis inclusis; sporangiis primo ad venas frondium valde contractarum restrictis laminam deinde obtebentibus.

Species unica cognita:

QUERCIFILIX ZEYLANICA (Houttuyn) Copeland, comb. nov.

Ophioglossum zeylanicum HOUTTUYN, Nat. Hist. 14 (1783) 43, pl. 43, fig. 1; CHRISTENSEN, Index Fil. (1906) 472.

Rhizome rather slender, creeping, scaly. Stipes approximate, short, 2 to 4 cm long, sparsely scaly at the base and pubescent throughout. Sterile frond 6 to 10 cm long, 3 to 5 cm wide, normally with one pair of sessile basal pinnæ, which are always dilated at their base, and usually large enough to make this decidedly the widest part of the frond. Above these, the body of the frond is pinnately lobed with roundish lobes, and the apex is rounded. A main vein enters each lobe, but does not reach its apex; otherwise, except in basal pinnæ which themselves are lobed, there are no main veins. The venation is rather irregular, perhaps in correlation with the small size; free included veinlets are fairly numerous, but without any regularity. Fertile frond of the same design, but small and long-stalked, its divisions only 2 to 3 mm wide, the basal ones often forked.

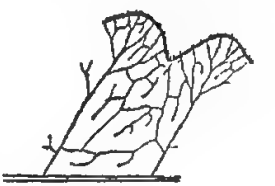


FIG. 52. *Quercifilix zeylanica* (Houttuyn) Copeland, comb. nov.; Hong Kong.

This fern has been called *Ophioglossum, Osmunda, Acrostichum, Onoclea, Gymnopteris, Leptochilus, Dendroglossa,* and *Polybotrya.* It is in all herbaria, and in cultivation, and has been figured repeatedly. *Acrostichum* and *Gymnopteris* were reasonable names in their time; but it has had no generic name that it can keep when a genus is construed as a group composed of species related, instead of merely similar. If it had to be placed in any one of to-day's genera, this would most conveniently be *Hemigramma,* and most properly be *Tectaria.* I do not believe that any descendant of the Polypodieæ inherits the possibility of producing such hairs as clothe its stipe, nether surface and margin. Fée tried to establish a genus *Dendroglossa,* composed of this species and *Hemigramma,* but this was not the *Dendroglossa* of Presl, which is indisputably polypodiid in origin. I believe *Quercifilix* to be tectarid, but not, within *Tectaria,* of common origin with *Hemigramma.* The source of the latter is clearly in the affinity of *T. decurrens.* The probable source of *Quercifilix* is in the quite distinct group represented, for example, by *Tectaria labrusca.*

The wide dissemination of *Quercifilix*—Mauritius and Ceylon to Formosa and Borneo—and its uniformity wherever it has

been found, indicate a very considerable age. It does not remain in such a plastic condition as does *Hemigramma latifolia.*

SPECIES EXCLUDENDAE

LEPTOCHILUS (CHRYSODIUM) RAAPII v. A v. Rosenburgh, Bull. Dept. Agr. Ind. Néerl. 18 (1908) 27, pl. 8.

This is a true *Acrostichum,* as shown by the shape, texture, and venation of the pinnæ, erect caudex, and densely clustered stipes, and most definitely by the narrow, dark paleæ with lighter-brown margins. It is to be suspected of being juvenile *Acrostichum aureum.*

DRYOPTERIS CELEBICA (Baker) Copeland, comb. nov.

Acrostichum celebicum BAKER, Kew Bull. (1901) 145.
Leptochilus celebicus C. CHRISTENSEN, Index Fil. (1905) 384.

Baker's citations of specimens are: *Curtis 431* and *Sauvinière 61,* of which I have Sauvinière's from Kew. Neither stipe nor rachis is really naked, and the pinnæ are mostly coarsely serate, rather than "leviter pinnatifidis" with obtuse lobes. However, in the absence of opportunity to compare the two collections, I accept Baker's judgment of their identity, and keep his specific name for Sauvinière's plant. It is clearly a member of the *Dryopteris canescens* group, very rich in species as well as in names, in Celebes and the Philippines. It is near to, but not identical with, *Aspidium canescens* forma *acrostichoides* Christ, Ann. Jard. Bot. Buit. 15 (1898) 132, which may be identical with the same author's var. *acrostichoides,* Philip. Journ. Sci. § C 2 (1907) 200, of his "new subspecies," *D. diversiloba* (Presl). It is likewise nearly related to *Dryopteris hosei* (Baker) C. Christensen.

For the correct assignment of the following four species, I am indebted to Dr. Carl Christensen. None of them seemed to fit well in any genus ever included in *Leptochilus,* but their correct placing was not possible from the published descriptions alone. Knowing that Doctor Christensen was engaged with the ferns of Borneo, and in possession of the necessary authentic specimens from Kew, I asked his help, and he has very kindly advised me as follows:

ACROSTICHUM EXSCULPTIUM Baker, Journ. Bot. 26 (1888) 326.

"Is to the smallest details identical with *Meniscium stenophyllum* Baker (*Dryopteris brevipinna* C. Chr.), now **Dryopteris exsculpta** (Baker) C. Chr."

ACROSTICHUM ANTROPHYOIDES Baker, Journ. Linn. Soc. Bot. 22 (1886) 231.

"This is *Loxogramme iridifolia* (Christ) Copel., now **Loxogramme antrophyoides** (Baker) C. Chr."

This is well known in Borneo, as well as in Celebes and the Philippines, under Christ's specific name. The parties to the nomenclatorial history of this species make it particularly pertinent to recall here Christ's review of Christensen's Index, in which Christ berated the changer of names, and maintained that the real service to botany was performed by the man who recognized and described a new species, and that there is material injustice in making his name subordinate to that of one who merely changes the generic name. With full reverence for Doctor Christ, who would have required a revelation to know that he was redescribing Baker's species, I think it is clear here that the real service is neither Christ's nor Baker's, but Christensen's.

ACROSTICHUM MODESTUM Baker, Journ. Linn. Soc. Bot. 22 (1886) 231.

"According to a sterile specimen in herb. Christ from the type collection, identical with a fertile specimen from the Sarawak Museum, this is technically a simple-fronded *Tectaria*, in habit resembling *Diplazium lanceum*."

ACROSTICHUM OLIGODICTYON Baker, Journ. Linn. Soc. Bot. 24 (1887) 261.

"This is a member of the meniscioid group of *Dryopteris*, closely related to *D. exsculpta, D. hosei, D. firmula,* and others, and is **Dryopteris oligodictya** (Baker) C. Chr."

ILLUSTRATIONS

PLATE 1

Leptochilus axillaris (Cavanilles) Kaulfuss; *a*, abnormal, partly fertile fronds; *b*, branch showing axillary buds.

PLATE 2

Leptochilus platyphyllus Copeland, sp. nov.; type.

PLATE 3

Campium linnaeanum (Fée) Copeland, comb. nov.; *a*, atavistic form; *b*, typical form.

PLATE 4

FIG. 1. *Campium minus* (Fée) Copeland, comb. nov.; *Cuming 326*, in herbarium Copeland.
2. *Campium dilatatum* Copeland, sp. nov.; type.

PLATE 5

FIG. 1. *Campium laciniatum* Copeland, sp. nov. (?), simple form.
2. *Campium lanceolatum* (Fée) Copeland, comb. nov.; small specimen, from Concan.

PLATE 6

Campium ovatum Copeland, comb. nov.; type.

PLATE 7

Campium laciniatum Copeland, sp. nov.; type.

PLATE 8

Campium subsimplex (Fée) Copeland, comb. nov.; imperfectly pinnate form.

PLATE 9

Campium hydrophyllum Copeland, comb. nov.; type.

PLATE 10

Campium nigrum Copeland, sp. nov.; type.

PLATE 11

Campium pseudoscalpturatum Copeland, sp. nov.; type.

PLATE 12

Campium foxworthyi Copeland, sp. nov.; type.

PLATE 13

Campium tenuissimum Copeland, sp. nov.; type.

PLATE 14

Campium cuspidatum (Presl) Copeland, comb. nov.; *Cuming 161.*

PLATE 15

Campium validum Copeland, sp. nov.; type.

PLATE 16

Campium subcordatum Copeland, sp. nov.; type.

PLATE 17

Campium interlineatum Copeland, sp. nov.; type.

PLATE 18

Campium palustre (Brackenridge) Copeland, comb. nov.; type.

PLATE 19

Campium samoense Copeland, sp. nov.; type.

PLATE 20

Campium rivulare (Brackenridge) Copeland, comb. nov.; type.

PLATE 21

Campium parvum Copeland, sp. nov.; type.

PLATE 22

Campium argutum (Fée) Copeland, comb. nov.; large form, *McLean et al. s. n.*

PLATE 23

Campium semicordatum (Baker) Copeland, comb. nov.; cotype on the right.

PLATE 24

Capium semicordatum (Baker) Copeland, comb. nov.; collected by Beddome.

PLATE 25

Campium lanceum Copeland, sp. nov.; type.

PLATE 26

Campium crispatulum (Wallich) Presl; Wallich specimen in the Kew Herbarium.

PLATE 27

Campium undulatum (Wallich: Hooker) Presl; type.

PLATE 28

Campium bradfordi Copeland, sp. nov.; type.

PLATE 29

Campium molle Copeland, sp. nov.; type.

PLATE 30

Campium acrostichoides (Afzelius) Copeland, comb. nov.; Sierra Leone, *Scott Elliott 4048.*

PLATE 31

pium angustifolium Copeland, sp. nov.; type.

PLATE 32

pium fluviatile (Hooker) Copeland, comb. nov.; cotype.

TEXT FIGURES

figures were drawn five times natural size and reduced to twice natural size, except fig. 36, which is a copy of Hooker's figure.]

1. *Campium linnaeanum* (Fée) Copeland, comb. nov.; Davao.
2. *Campium minus* (Fée) Copeland, comb. nov.; a normal leaf from Los Baños, Laguna. Free included veinlets are usually much more numerous.
3. *Campium minutulum* (Fée) Copeland, comb. nov.; Khasia, *Hooker and Thomson.*
4. *Campium dilatatum* Copeland, sp. nov.; type.
5. *Campium metallicum* (Beddome) Copeland, comb. nov.
6. *Campium lanceolatum* (Fée) Copeland, comb. nov.; peninsular India.
7. *Campium decurrens* (Blume) Copeland, comb. nov.; Java, *Winckel 1335B.*
8. *Campium zeylanicum* (Fée) Copeland, comb. nov.
9. *Campium ovatum* Copeland, comb. nov.; type. Frond simple.
0. *Campium laciniatum* Copeland, sp. nov.; type.
1. *Campium subsimplex* (Fée) Copeland, comb. nov.; *Bolster 244.*
2. *Campium hydrophyllum* Copeland, comb. nov.; type. Frond simple.
3. *Campium heteroclitum* (Presl) Copeland, comb. nov.; *Cuming 5.*
4. *Campium nigrum* Copeland, sp. nov.; type.
5. *Campium diversifolium* (Blume) Copeland, comb. nov.; Java, *Palmer and Bryant 555.*
6. *Campium pseudoscalpturatum* Copeland, sp. nov.; type.
7. *Campium foxworthyi* Copeland, sp. nov.; type.
8. *Campium tenuissimum* Copeland, sp. nov.; type.
9. *Campium cuspidatum* (Presl) Copeland, comb. nov.; *a*, from *Cuming 161; b*, from cotype of *Gymnopteris inconstans* Copeland.
0. *Campium quoyanum* (Gaudichaud) Copeland, comb. nov.; *a*, Mindanao, *Elmer 13458'; b, Acrostichum repandum* Blume, Java, *Mousset 140; c, Campium quoyanum*, China, United States National Herbarium, No. 232248; *d*, near *Campium quoyanum*, Todaya, Mindanao, *Copeland s. n.*
1. *Heteroneuron sinuosum* Fée; cotype.
2. *Campium validum* Copeland, sp. nov.; type.
3. *Campium subcordatum* Copeland, sp. nov.; *a*, type; *b*, cotype.
4. *Campium interlineatum* Copeland, sp. nov.; type.
5. *Campium palustre* (Brackenridge) Copeland, comb. nov.; Tahiti, *Setchell and Parks 435.*
6. *Campium samoense* Copeland, sp. nov.; type.
7. *Campium rivulare* (Brackenridge) Copeland, comb. nov.; Fiji, *Horne 694.*
8. *Campium parvum* Copeland, sp. nov.; type.

FIG. 29. *Campium arguium* (Fée) Copeland, comb. nov.
30. *Campium bipinnatifidum* (Mettenius) Copeland, comb. nov.; Seychelles.
31. *Campium semicordatum* (Moore: Baker) Copeland, comb. nov.; *a*, cotype; *b*, India, *Beddome*.
32. *Campium lanceum* Copeland, sp. nov.; type.
33. *Campium angustipinnum* (Hayata) Copeland, comb. nov.; *a*, Formosa, *Faurie 231; b*, Sikkim, *Jerdon*.
34. *Campium crispatulum* Presl; Kamoun, *Wallich 24*.
35. *Campium scalpturatum* (Fée) Copeland, comb. nov.; Lamao, *Copeland 249*.
36. *Campium undulatum* (Wallich: Hooker) Presl; drawing after Hooker.
37. *Campium costatum* (Wallich) Presl; *a*, from Assam; *b*, from Chittagong.
38. *Campium deltigerum* (Wallich) Copeland, comb. nov.; Sikkim, *Thomson s. n.*
39. *Campium virens* (Wallich: Hooker and Greville) Presl; *a*, Sikkim, *J. D. Hooker; b*, Siam, *Eryl Smith 1112*.
40. *Campium bradfordi* Copeland, sp. nov.; type.
41. *Campium molle* Copeland, sp. nov.; type.
42. *Campium subcrenatum* (Hooker and Greville) Presl; *a*, Cochin, *Gamble 14815 cult.; b*, southern India, *Gough 61*.
43. *Campium féeianum* Copeland, nom. nov.; Concan, *Law s. n.*
44. *Campium acrostichoides* (Afzelius) Copeland, comb. nov.
45. *Campium humblotii* (Baker) Copeland; Bé Kitus Mountains, northeastern Madagascar, *J. B. Last*, 1900.
46. *Campium salicinum* (Hooker) Copeland, comb. nov.; cotype.
47. *Campium angustifolium* Copeland, sp. nov.; type.
48. *Campium gemmiferum* (Hieronymus) Copeland, comb. nov.; Niger, *I. Barter*.
49. *Campium auriculatum* (Lamarck) Copeland, comb. nov.; Mauritius.
50. *Campium fluviatile* (Hooker) Copeland, comb. nov.; cotype with short-hastate frond, Fernando Po.
51. *Campium gaboonense* (Hooker) Copeland, comb. nov.; *Zenker 3306*.
52. *Quercifilix zeylanica* (Houttuyn) Copeland, comb. nov.; Hong Kong.

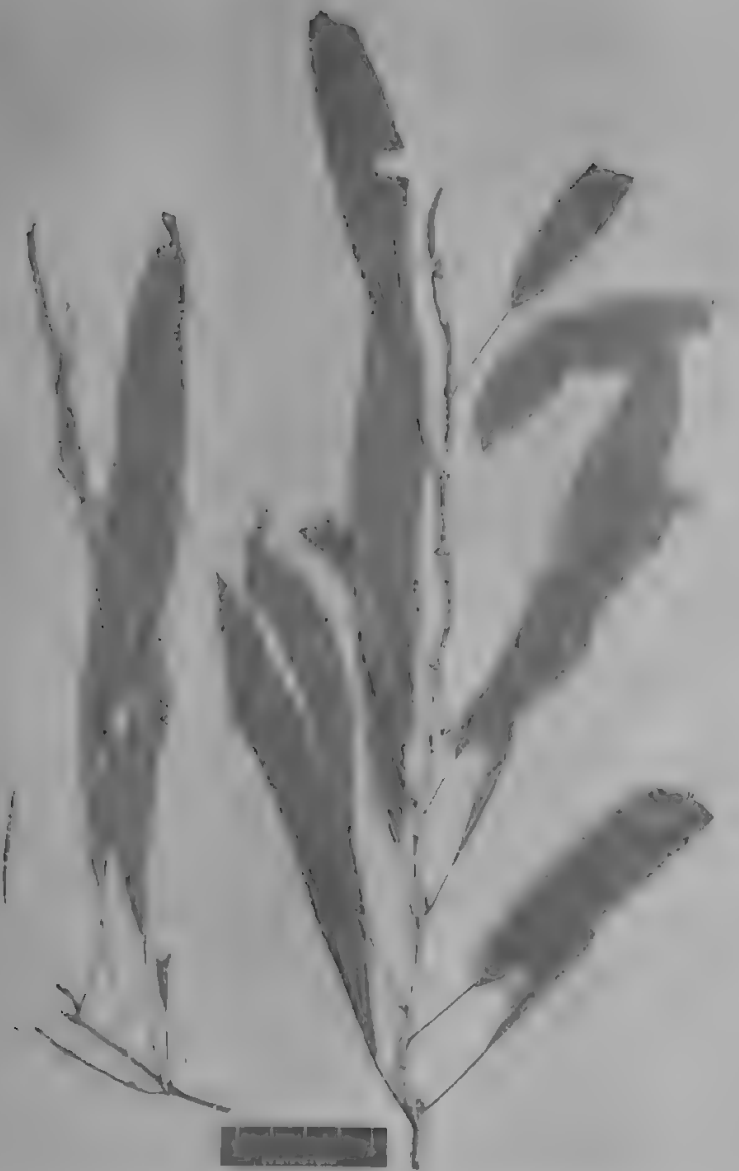


PLATE 1. LEPTOCHILUS AXILLARIS (CAVANILLES) KAULFUSS: A, ABNORMAL, PARTLY FERTILE FRONDS; B, BRANCH SHOWING AXILLARY BUDS.

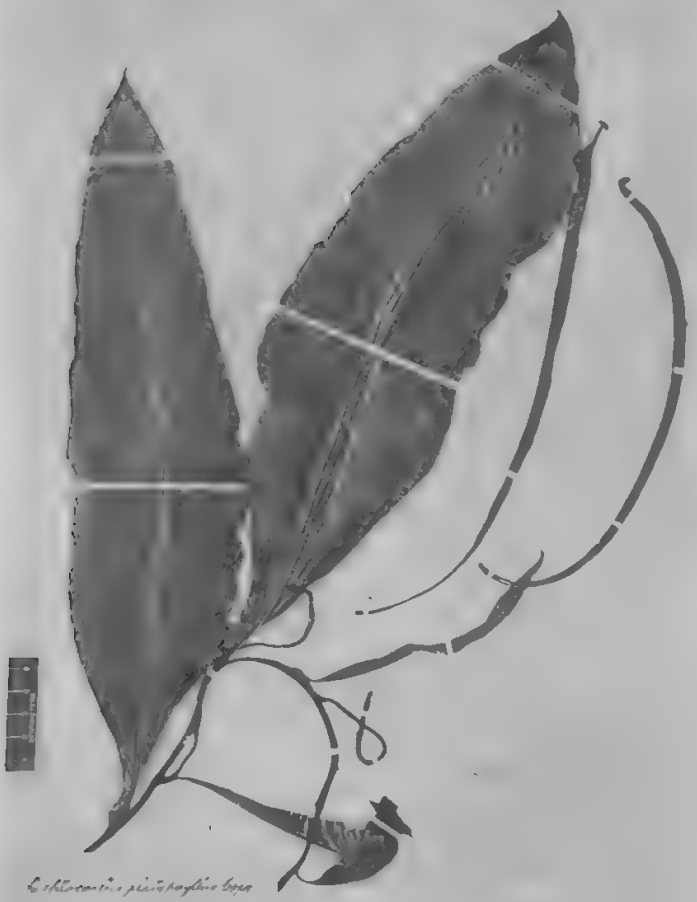


PLATE 2. LEPTOCHILUS PLATYPHYLLUS COPELAND, SP. NOV.: TYPE.

PLATE 3. CAMPIUM LINNAEANUM (FÉE) COPELAND, COMB. NOV.: A, ATAVISTIC FORM; B, TYPICAL FORM.

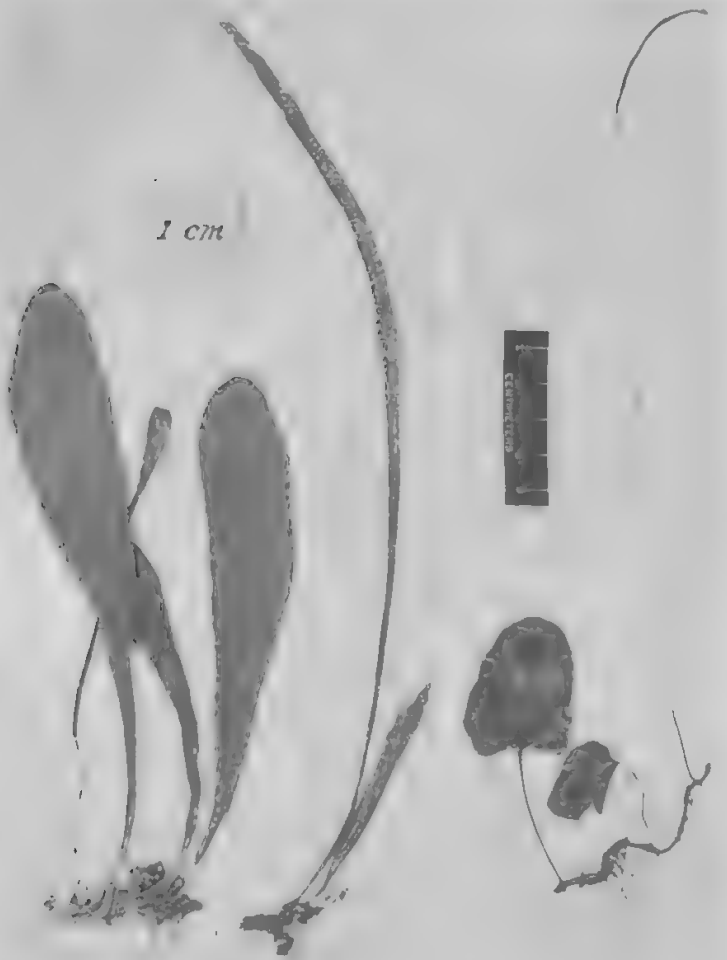
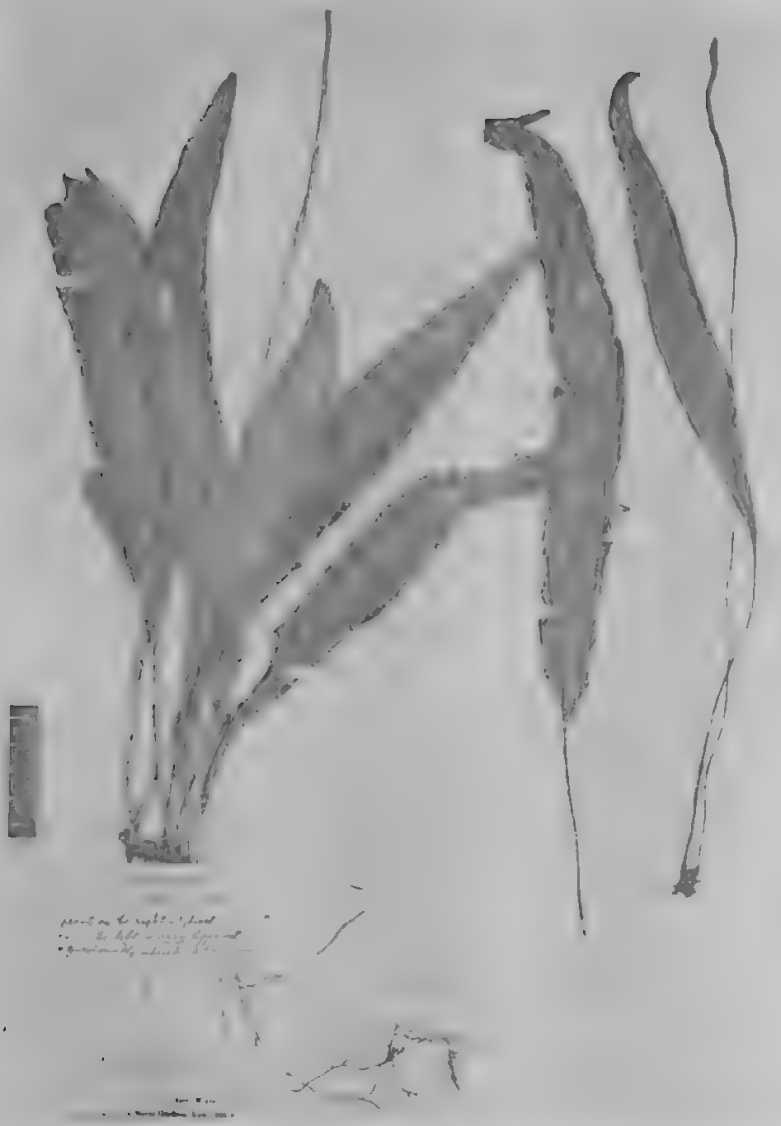


Fig. 1. Campium minus (Fée) Copeland, comb. nov.: Cuming 326, in herbarium Copeland.
2. Campium dilatatum Copeland, sp. nov.: type.

PLATE 4.



1 2

Fig. 1. Campium laciniatum Copeland, sp. nov. (?), simple form. 2. Campium lanceolatum (Fée) Copeland, comb. nov.; small specimen, from Concan.

PLATE 5.

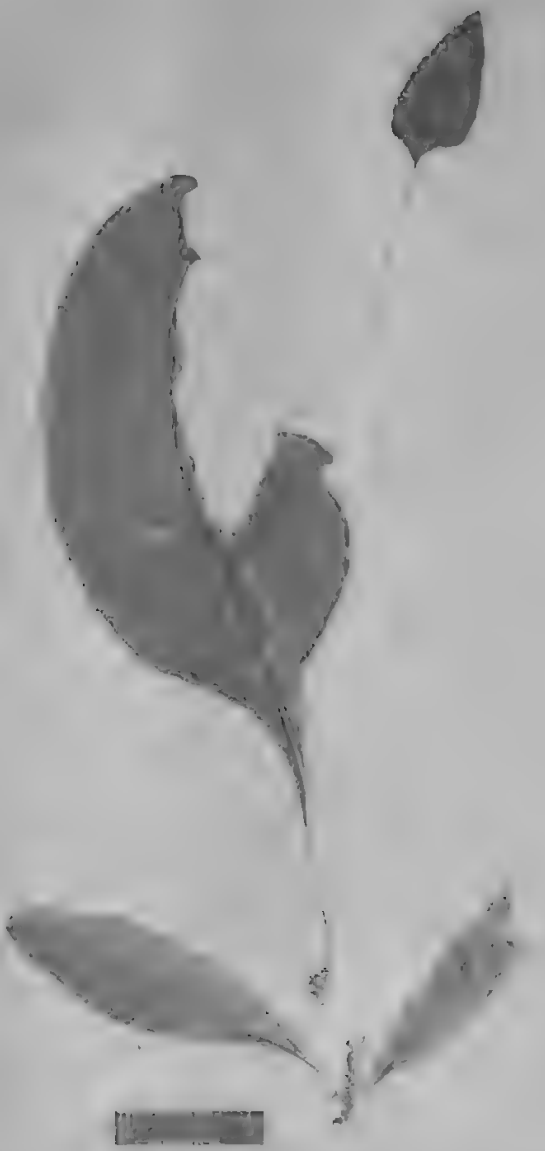


PLATE 6. CAMPIUM OVATUM COPELAND, COMB. NOV.; TYPE.

PLATE 7. CAMPIUM LACINIATUM COPELAND, SP. NOV.: TYPE.

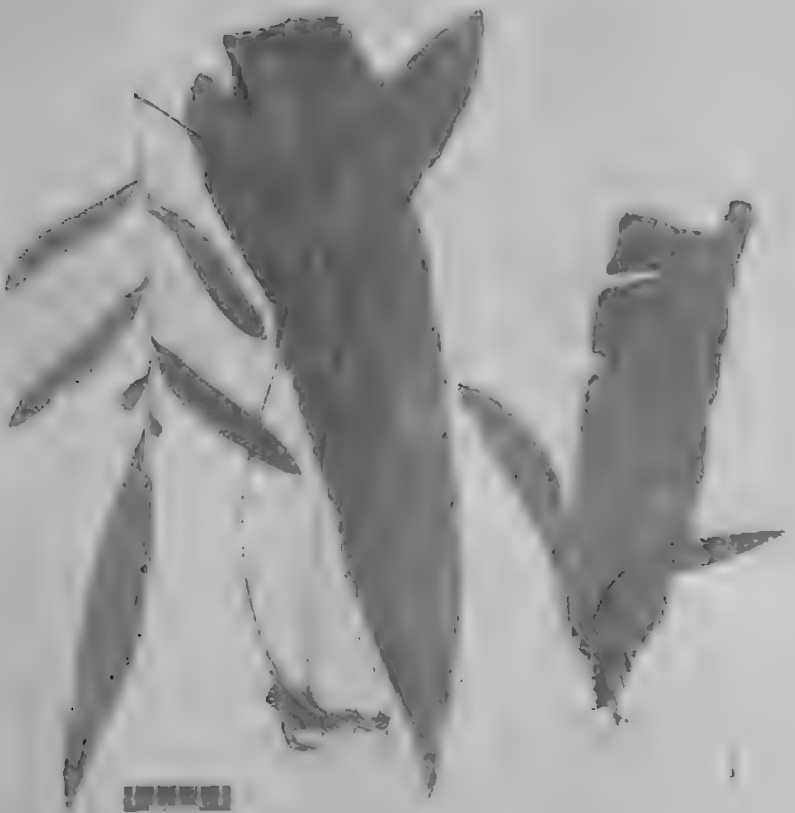


PLATE 8. CAMPIUM SUBSIMPLEX (FÉE) COPELAND, COMB. NOV.: IMPERFECTLY PINNATE FORM.

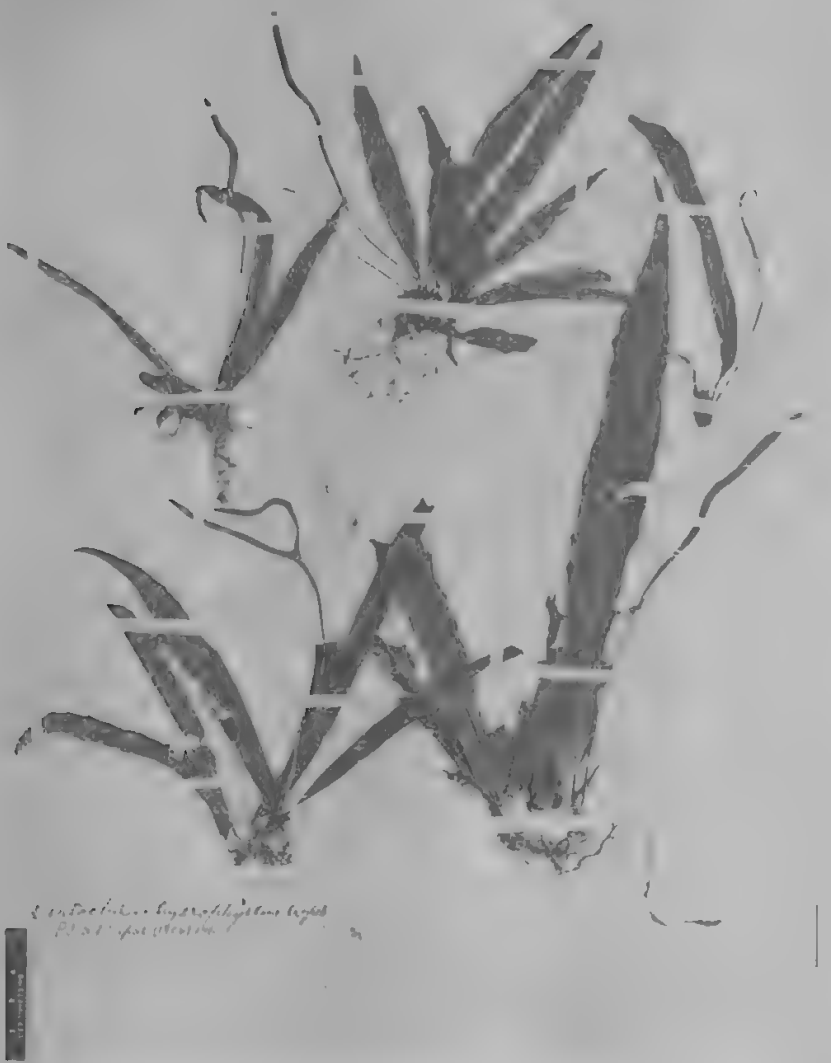


PLATE 9. CAMPIUM HYDROPHYLLUM COPELAND, COMB. NOV.; TYPE.

PLATE 10. CAMPIUM NIGRUM COPELAND, SP. NOV.; TYPE.

PLATE 11. CAMPIUM PSEUDOSCALPTURATUM COPELAND, SP. NOV.; TYPE.

PLATE 12. CAMPIUM FOXWORTHYI COPELAND, SP. NOV.; TYPE

PLATE 13. CAMPIUM TENUISSIMUM COPELAND, SP. NOV.; TYPE.

PLATE 14. CAMPIUM CUSPIDATUM (PRESL) COPELAND, COMB. NOV.: CUMING 161.

PLATE 13. CAMPIUM VALIDUM COPELAND, SP. NOV.; TYPE.

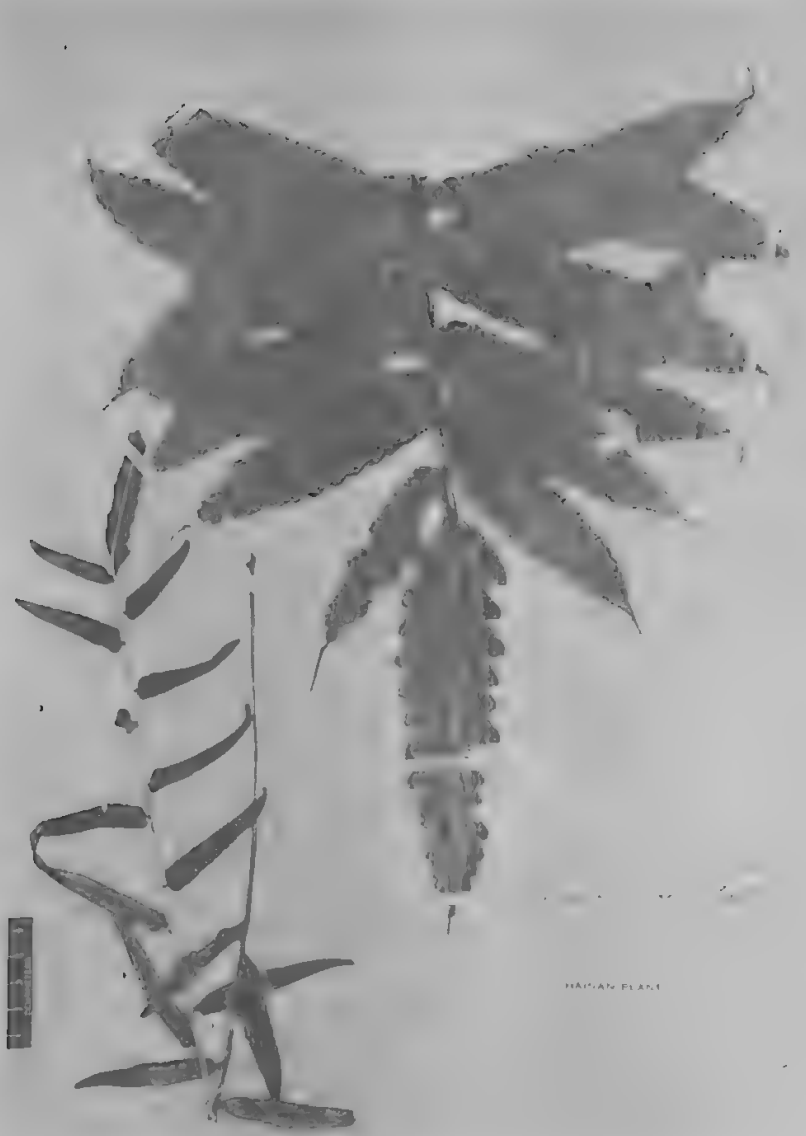


PLATE 16. CAMPIUM SUBCORDATUM COPELAND, SP. NOV.; TYPE.

PLATE 17. CAMPIUM INTERLINEATUM COPELAND, SP. NOV.; TYPE.

PLATE 18. CAMPIUM PALUSTRE (BRACKENRIDGE) COPELAND, COMB. NOV.: TYPE.

PLATE 19. CAMPIUM SAMOENSE COPELAND, SP. NOV.; TYPE.

PLATE 20. CAMPIUM RIVULARE (BRACKENRIDGE) COPELAND, COMB. NOV.; TYPE.

PLATE 21. CAMPIUM PARVUM COPELAND, SP. NOV.; TYPE.

PLATE 22. CAMPIUM ARGUTUM (FÉE) COPELAND, COMB. NOV.: LARGE FORM, McLEAN ET AL., S. N.

PLATE 23. CAMPIUM SEMICORDATUM (BAKER) COPELAND, COMB. NOV.: LOTYPE ON THE RIGHT.

PLATE 24. CAMPIUM SEMICORDATUM (BAKER) COPELAND, COMB. NOV.: COLLECTED BY BEDDOME.

PLATE 25. CAMPIUM LANCEUM COPELAND, SP. NOV.; TYPE.

PLATE 26. CAMPIUM CRISPATULUM (WALLICH) PRESL; WALLICH SPECIMEN IN KEW HERBARIUM.

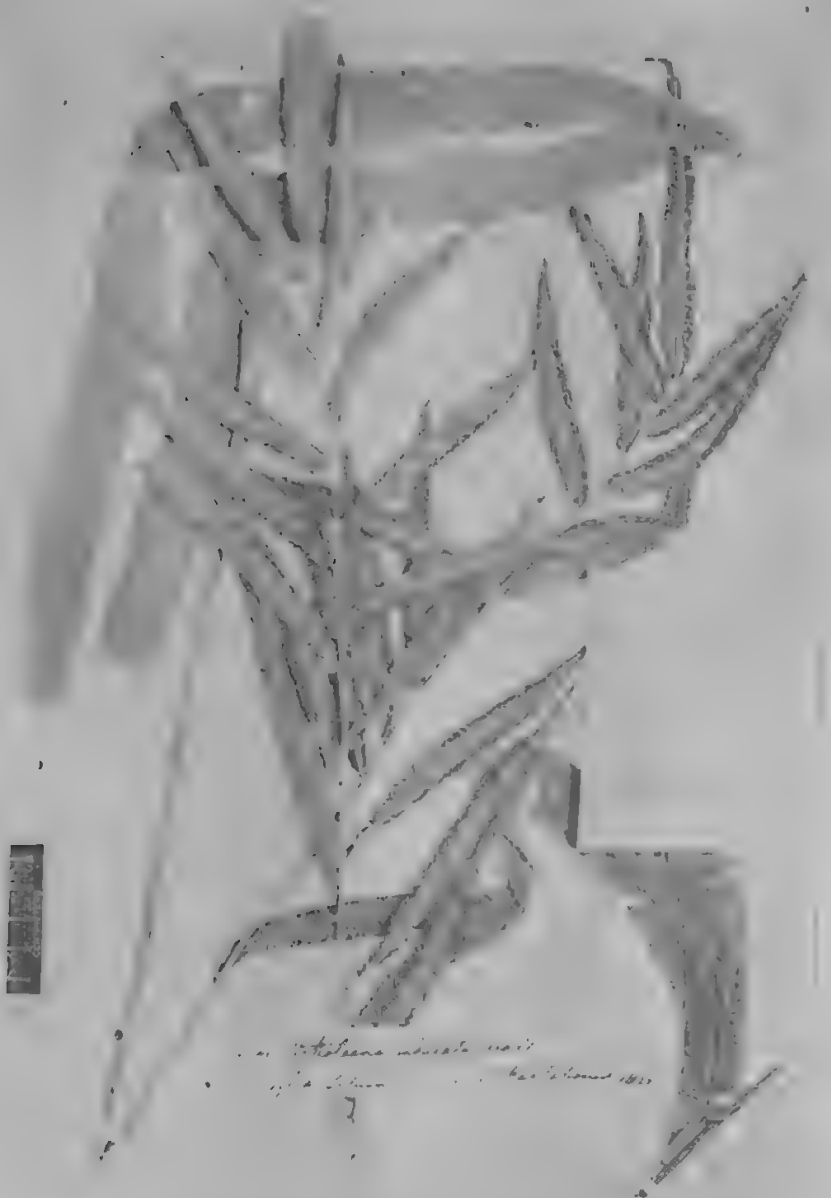


PLATE 27. CAMPIUM UNDULATUM (WALLICH: HOOKER) PRESL; TYPE.

PLATE 25. CAMPIUM BRADFORDI COPELAND, SP. NOV.; TYPE.

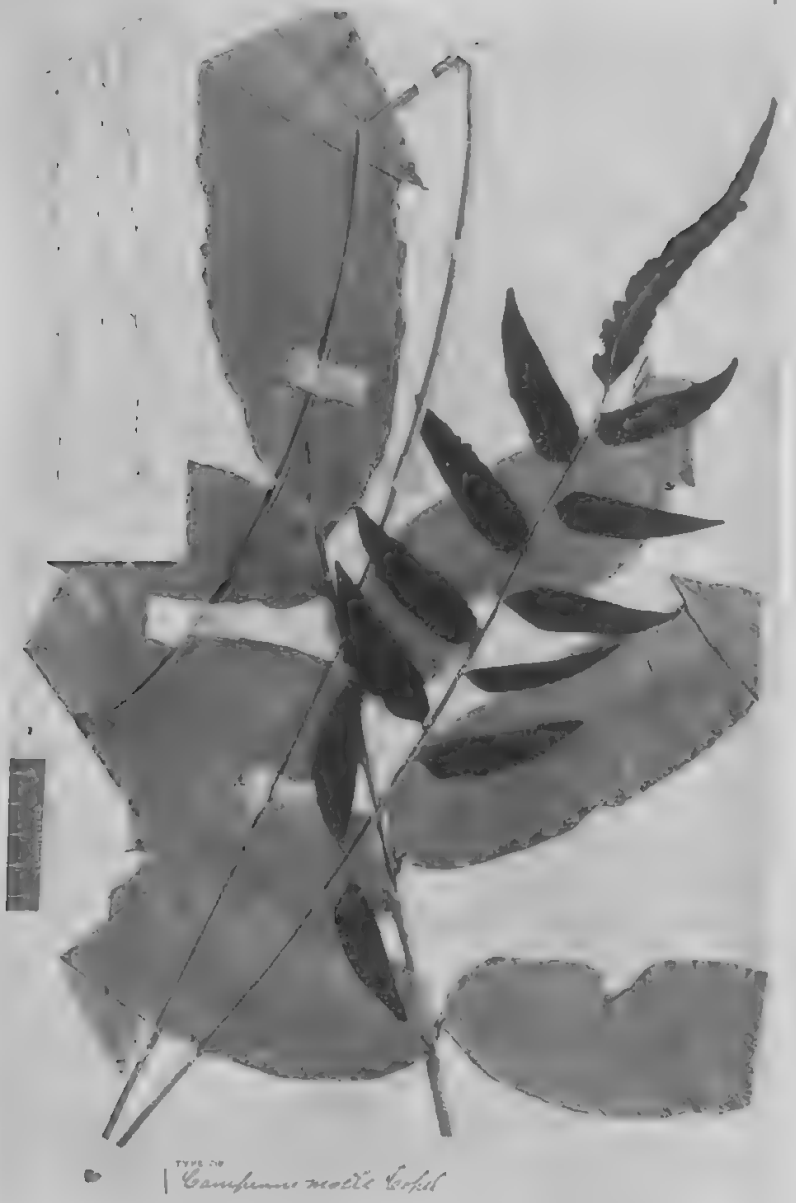


PLATE 29. CAMPIUM MOLLE COPELAND, SP. NOV.; TYPE.

PLATE 31. CAMPIUM ANGUSTIFOLIUM COPELAND, SP. NOV.: TYPE.

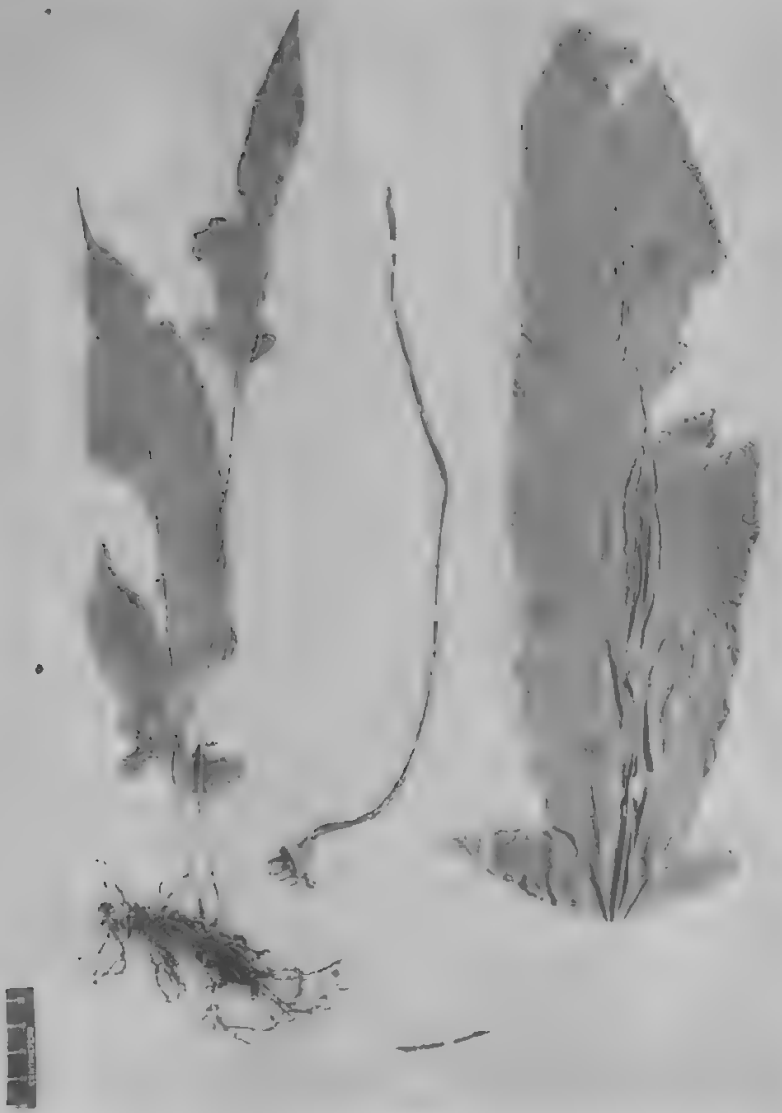


PLATE 32. CAMPIUM FLUVIATILE (HOOKER) COPELAND, COMB. NOV.; COTYPE.

A CYTOLOGICAL STUDY OF COCOS NUCIFERA LINNÆUS

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SEVEN PLATES

For many years the reduction divisions in the mother cells have been studied and described in various forms with the object of determining the time, the nature, and the extent of the sequence of events during the process. The structure, the behavior, and the differentiation among chromosomes and the part they play in heredity have been also carefully considered. That the number of chromosomes is reduced to one-half previous to the union of the gametes became universally accepted, but the method by which reduction divisions or meiotic divisions are accomplished is still not so clear, because of the numerous diversified accounts and confusing views regarding the details of meiotic divisions, which need not be reviewed here. The diversity of opinion is partly due first, to the complexity of the process, coupled with certain unavoidable flaws in the technic essential to the study of the process; second, to the difficulty of interpreting the details of the series of stages under the condition in which the delicate material is studied; and, third, to the specific differences exhibited by the various organisms during the meiotic divisions. Any additional cytological study, therefore, is of considerable interest. Since the anthers of *Cocos nucifera* Linnæus are rather favorable material for such an investigation, this piece of work was undertaken with the hope of throwing more light upon the phenomenon of synezesis, or synapsis, and its relation to reduction division.

MATERIAL AND METHODS

The material used in this study was collected from two places in Luzon, Philippine Islands, where the tree is extensively cultivated. One portion of it was collected on April 7, 1926, from Mauban, Tayabas Province, while the other and the greater portion was collected on May 13, 1926, from San Pablo, Laguna Province. The two sets of material were fixed in the field from

the inflorescences just beginning to emerge from the axils of the leaves. The samples were taken from the different parts of the inflorescence and fixed separately. Thus, those taken from the tips of the spikes were fixed separately from those taken from the middle part and separately from those collected from the base.

The fixing fluids used were 1 per cent chrom-acetic acid with ten to fifteen drops of 1 per cent osmic acid to 50 cubic centimeters of the solution, and Flehmming's strong chrom-osmic acetic acid solution. The young anthers were mostly cut into two parts and some were trimmed at both ends of the anther before they were placed in the fixing fluids. Both fixatives gave fairly satisfactory results.

The material was embedded in 50° to 52° C. paraffin, and cut from 5 to 10 μ thick with some 10 to 15 μ thick and stained with Haidenhain's iron-alum hæmatoxylin.

RESTING STAGE TO SYNEZESIS

The pollen mother cells following the last mitosis in the archesporium are more or less polygonal in outline and fit tightly together with no spaces between them. There is as yet no rounding of the cell wall. The cytoplasm is exceedingly dense and granular with a very few small vacuoles. The nucleus is comparatively large, somewhat spherical, and possesses a well-defined nuclear membrane. It is usually found lying very close to one side of the cell, especially during prophase and synezesic stages; but soon after the spireme begins to emerge and spread throughout the nuclear cavity, the nucleus seems to move toward the central part of the cell. There were comparatively few cases in which the nucleus was found close to one side of the cell during the open spireme stage. Even in such cases, the position of the nucleus compared with that in the earlier stages is farther from the wall.

The scarcity of the resting stage of the nucleus, during the early stage of the anthers of *Cocos nucifera*, seems to indicate that it lasts only for a short time, for it soon goes into prophase. Plate 1, fig. 1, represents a definite resting stage. It is characterized by the somewhat uniformly distributed chromatin reticulum throughout its cavity. At the intersections between the chromatin threads and the delicate fibers connecting them there are very minute nodelike structures or granules of different sizes. During this stage the chromosomes were completely resolved into a network of threads and their indivi-

duality is completely lost. There is no trace whatever of parallelism of the threads.

Heterotypic prophase.—The early prophase of the first meiotic division is differentiated from the resting stage by the gradual and progressive increase in size of the chromatin granules or nodelike structures in the reticulum, the thickening and contraction of the threads, and the decided enlargement of the nucleus. As the nuclear changes advance, the granules come closer together and take a deeper stain, while the chromatin threads contract and become thicker and shorter. The reticulum as a whole loses the even and uniform characteristic, as represented on Plate 1, fig. 2. The meshes become larger and different in size. Some of the threads which have been lying far apart are apparently brought near together by their gradual contraction. Plate 1, fig. 3, shows the condition of the reticulum before synezesis. The chromatin threads are irregularly thickened, the nodal structures are more prominent, and the meshes become smaller.

Synezesis.—The gradual withdrawal of the chromatin threads, or network, from the nuclear membrane marks the beginning of synezesis or synapsis as represented on Plate 1, fig. 4. During the progress of events leading to this stage there is a notable and irregular progressive increase in diameter of the threads, which seems to be brought about not only by contraction but also by fusion of material from the chromatin threads that happen to run parallel to one another. Furthermore, there is an indication of a flow of material from one thread to another, or from one part of a thread to another part, similar to what Cleland(5) observed in *Oenothera franciscana.* A greatly enlarged portion of the thread is represented on Plate 1, fig. 5. The contraction continues steadily until almost all the threads and meshes in the reticulum are drawn into a more or less compact mass that lies usually near the side of the large nucleolus and at one side of the nuclear cavity. At this stage the chromatin material appears as a lumpy mass with some globular projections, and a few small loops may be found on one or two sides of the synezesic knot. The pollen mother-cell nucleus remains in this condition for a long period, for the majority of the nuclei of the pollen mother cells of the younger anthers are usually observed in synezesis. A series of stages leading to synezesic contraction are represented on Plate 1, figs. 6 and 8, and on Plate 2, figs. 9 and 10. Very frequently fine strands extend across the nuclear cavity. Plate 1, fig. 7, shows a portion of

a greatly magnified spireme taken from the nucleus represented in fig. 6. Figure 10 represents a definite stage of synezesis after a maximum contraction is attained. The nature of the spireme at this stage is very difficult to determine with accuracy. A careful examination of some thin tangential sections, however, seems to reveal that the chromatin nodes, or granules, were brought very close together by contraction. These granules are found arranged in most cases in single rows and in a very few instances in two rows running side by side. Since these few cases of the parallel arrangement of the granules are so rare in the material examined it is quite obvious that the spireme is univalent in nature. From this fact the condition observed in *Cocos nucifera* can by no means be compared either with Digby's(9) findings in *Osmunda* or with the writer's(20, 21) in *Elodea*, in which the parallel arrangement of the granules or the double nature of spireme is very evident. All the indications tend to agree with the observations of Cleland(5) on *Oenothera*, in which the scattered chromatin granules from a thin-thread reticulum are brought together into a thick spireme by a process that consists largely of the contraction of certain threads and the absorption of their contents into the body of other threads, a process which he believes involves occasional parallelism. Plate 2, fig. 11, represents a very small portion of the spireme in the same stage as fig. 10.

That the synezesis is brought about by the contraction of the chromatin reticulum and by the decided enlargement of the nucleus, as has been definitely observed in *Lactuca* by Gates and Rees(13) and in *Elodea* by the writer(20, 21), is also very evident in *Cocos nucifera*. When the size of the contracted reticulum is compared with that of the resting condition and the cavity of this nucleus with that of the synezesic stage a relatively great difference is noted. The synezesic knot is distinctly smaller than the original reticulum, while the cavity of the resting stage is comparatively smaller than that of the synezesic stage. This is essentially contrary to Lawsons's view point.

The nucleolus may, or may not, be entirely inclosed by the chromatin knot. Generally, however, it is found at one side of the synezesic knot, and sometimes is partly covered by a few projecting loops of the spireme. There is no material change observed in the nucleolus up to this stage except that it has increased in size, almost twice as much as during the resting stage.

Open spireme.—After the period of the greatest contraction, the chromatin mass begins to loosen and it becomes a continuous univalent short and thickened thread, known as the spireme, which extend slowly throughout the nuclear cavity. Free ends are rarely observed. During this gradual distribution of the spireme, beautiful loops corresponding to the gametic number of the chromosomes are formed. At this stage the spireme appears more uniform in diameter, although in some places it may have an irregular thickening. Plate 2, figs. 12, 13, and 15, illustrates this gradual unfolding of the spireme from the synezesic knot. Judging from the frequency of this stage in the several sections examined, it appears to be of long duration. There is no sign of splitting observable, and the spireme, unlike that of *Elodea*,(20, 21) does not show the double nature. The spireme is distinctly single and more or less smooth and uniform. Plate 2, fig. 14, is a detailed drawing of a greatly magnified portion of the spireme taken from a superficial section.

While the spreading of the spireme is taking place the nucleolus begins to separate from the spireme and its size is gradually reduced. This reduction of the size of the nucleolus is significant. It seems that the nucleolar content contributes in someway to the formation of the thick spireme. Cleland(5) shows a figure that indicates a clear connection between the nucleolus and one end of the spireme. It is also quite evident that the nucleolus at this stage takes the stain very lightly, and a few clear rounded spaces are developed.

Second contraction.—Shortly after the spireme is uniformly spread into wide loops radiating throughout the nuclear cavity (Plate 3, fig. 16), the nucleous passes into another interesting phase of meiosis known as second contraction. Early stages leading to this phase are represented on Plate 3, figs. 17, 18, and 19. The first indication noticed is the gradual shortening and approximation of the sides of each loop and the progressive thickening and condensation of the chromatin thread. Up to this stage the chromatin thread remains distinctly single and there is no sign at all of fission.

As the process of shortening and condensation proceeds, the loops become shorter and thicker and their two sides approach each other closer and closer, while the spireme as a whole undergoes a slow process of transverse segmentation. The segmentation becomes evident from the time the loops begin to rearrange themselves in the nuclear cavity, and it is apparently

completed during the later stage of the second contraction. It is indicated by the formation of a constriction usually at the distal end of the loop (Plate 3, figs. 17 and 18). The loops are gradually detached while the massing of the filaments is going on. In a critical study of the chromatin filaments at this stage, particularly on the two sides of the loops, the writer failed to find any sign of longitudinal splitting or fission. This shows that each side of the loop represents a univalent chromosome, contrary to the interpretation of Gregoire(14, 15, 16) and his followers.

While the nucleus advances into second contraction, the greater part of the spireme filaments become gradually collected and entangled at the side of the nucleolus. During this period the visible identity of the individual parts of the spireme is somewhat lost, although in some cases isolated portions may remain independent and free. Plate 3, figs. 20 and 21, shows the character of the late stages of the second contraction in *Cocos nucifera*.

It is interesting to notice that during the later period of the second contraction there is a reduction in size of the nucleus. The pollen mother cells, which during the resting stage up to the later stage of synezesis were packed tightly together, are beginning to round off and separate from one another and large spaces among them are developed.

Diakinesis.—The massing of the chromatin material during the second contraction is of short duration only, for it soon loosens and proceeds into diakinesis. This is perhaps the reason why this stage was overlooked by some of the previous investigators. As the nucleus advances into this stage, the bivalent segments are gradually thrown toward the periphery of the nuclear cavity and they begin to show a somewhat clear outline. On Plate 3, fig. 21, the bivalent chromosomes in varying stages of evolution can be seen emerging from the knot of the second contraction. On one side of the nuclear cavity are three distinct loops coming out from the knot and moving toward the periphery, while on the other side one or two loops are in the process of organization. Some of the chromosomes are irregularly thickened and more or less spirally twisted along their entire lengths, others show distinctly a double character, still others are slender and have a somewhat uniform diameter. In the last the chromosomes are univalent but joined end to end. During this period of nuclear activity the chromosomes usually tend to assume a position close to the nuclear mem-

brane. This peripheral arrangement is especially conspicuous after considerable thickening and condensation of the chromosomes have occurred. The chromosomes represented on Plate 4, fig. 22, show a definite stage after the second contraction. On the same plate fig. 23 illustrates a more-advanced stage in which most of the young heterotypic chromosomes are lying close to the peripheral part of the nucleus.

While the paired chromosomes grow thicker and shorter the daughter chromosomes, or the members of the pairs, begin to separate or untwist. This process may be followed in a series of stages represented on Plate 4, figs. 23, 24, 25, 26*a*, and 26*b*, and Plate 5, fig. 27. The usual result of this separation, or untwisting, is the evolution of the configuration of the chromosomes into various shapes. In some cases they become more or less like J's, O's, X's, and Y's, but in very many cases they are found having the characteristic shapes of U's and V's. A few fine and delicate strands are observed connecting separate chromosomes, and some run from the chromosomes to either the nuclear membrane or nucleolus. These strands are obscurely granular, and they may appear straight, curved, or crooked. Sometimes they connect each other and form a sort of net (Plate 4, fig. 26*b*). The chromosomes now appear more homogeneous in structure, and they take more uniformly a deeper stain. Their outline is somewhat undulated, there is no splitting, and a great diversity is shown in their length. Plate 5, fig. 28, represents three greatly magnified bivalent chromosomes with Y, U, and X shapes and in the same stage as Plate 4, fig. 26.

Plate 5, fig. 29, represents an interesting stage after the greater contraction and thickening have occurred. The chromosomes present a ragged appearance. They are mostly V-shaped, although some possess either U or ring forms. There is no material increase in the number of strands connecting one chromosome to another or the chromosomes to the nuclear membrane. Still later stages of diakinesis are shown in figs. 30 and 31. The paired chromosomes appear definitely individualized with a more-distinct outline. Some of them simulate dumb-bell-shaped bodies, and others, straight and bent rods. As in the earlier stages, they are of different lengths and each chromosome is composed of two short structures, so closely appressed to one another that its double nature is often difficult to detect.

The number of bivalent chromosomes at this stage of the nuclear development was carefully considered. Several counts

from different sections and from different preparations were made. In general the bivalent number observed was sixteen, and in a very few instances fifteen. These few exceptional cases, however, can be accounted for as due to the frequent overlapping of the chromosomes.

During the late diakinesis stage and previous to the dissolution of the nuclear membrane, there is a notable decrease in size of the nucleolus and also of the nuclear cavity. The shape of the nucleolus, as well as of the nuclear cavity, is apparently modified from spherical to elongated or ovoid. The nucleolus, which stands out prominently during the earlier stages of the pollen mother cell because of its great affinity for stain, begins to show a marked decreasing affinity for the stain. Its nucleolar content is greatly reduced as shown by the fact that two or more clear round spaces or intra-nucleolar vacuoles are developed.

The nuclear membrane becomes more or less granular and irregular or wavy in outline. Its definite and smooth appearance is gradually lost, while the cytoplasm around it becomes denser and denser. That the nuclear membrane and the nucleolus disappear simultaneously at the time the fibers with granular appearance emerge from at least the three sides of nucleus is quite evident, as has been observed in *Elodea*.(20, 21) Plate 5, figs. 32 and 33, represents two characteristic stages, one closely following the other, of the late diakinesis. The multipolar spindle fibers are granular in structure and quite distinctly attached to the definite parts of the chromosomes. As the formation of the spindle fibers progresses, the nuclear cavity becomes smaller until it is completely filled by the fibers and by the dense cytoplasmic material. The chromosomes aggregate into a somewhat close irregular mass at the center of the pollen mother cell.

HETEROTYPIC MITOSIS

As the multipolar spindle fibers grow in number they are gradually rearranged into bipolars as indicated on Plate 5, fig. 34. The spindle fibers are seen stretching and have lost their granular character, while the chromosomes, which by this time have undergone a complete process of condensation, are moving toward the equatorial plane and they appear as bent rods, pestlelike, or somewhat globular. The chromosomes seem not to reach the equatorial region at the same time, but as soon as they reach this region, they become arranged more or less evenly in one plane and in a very symmetrical manner.

A polar view of the heterotypic chromosomes is shown in fig. 35. The sixteen bivalent chromosomes are very evident, and they display the same variation in shape. One of the sixteen heterotypic chromosomes is strikingly larger than the others, and the longitudinal fission between the two daughter chromosomes is very distinct, while three other chromosomes are smaller in size. They appear somewhat pestlelike and do not show longitudinal fission. This is one of the most favorable stages for counting the chromosomes for they are not crowded and seldom overlap each other. The several counts made at this stage revealed the same prevailing number, sixteen, that was obtained previously from the younger stages.

At the equatorial plate the heterotypic chromosomes may be arranged radially or obliquely. Each chromosome has a small bundle of spindle fibers attached to the inner end of each daughter segment, and the outer end extends perpendicularly from the spindle to the cytoplasm. In some cases, however, the chromosomes lying near the periphery or near the central part may be found arranged tangentially to the spindle. In this case the point of attachment of the spindle fibers to the daughter chromosomes may be at either end or at, or near, the middle region.

A typical side view of the metaphase stage of the heterotypic mitosis is represented on Plate 6, fig. 36. The general appearance is as if the contraction of the spindle fibers gradually pulled the two longitudinal halves apart. At the middle part, between the two separating daughter segments of each bivalent chromosome, there is a thickening which consists of the two ends that have not yet separated. Apparently, judging from this figure, all the chromosomes divide at the same time.

Soon after the daughter chromosomes have separated they immediately diverge at their equatorial ends, and take on the V-shaped or, sometimes, the J-shaped forms, with apex toward the pole.[9] As they move toward the poles, they pass through a slight process of condensation and differentiation until they reach the poles. In some cases a sign of splitting preparatory for the homœotypic mitosis is observed. Plate 6, fig. 37, represents an anaphase stage. The V- and J-shaped chromosomes are midway to the poles. A late anaphase is indicated in fig. 38. It illustrates the stage just after the daughter chromosomes have reached the poles. At this stage the chromosomes still retain their V- or J-shapes, although in some cases, their two ends are somewhat separated and appear as bent rods. Figure

39 shows a polar view of the sixteen univalent chromosomes at about the same stage as that of fig. 38. The fission of the chromosomes in preparation for the succeeding homœotypic mitosis becomes evident as they are congregated at the poles of the spindles. As the daughter chromosomes gather and mass together at the poles, they become surrounded by dense cytoplasm. Then a clear space, or vacuolelike region, developes between the chromosomes, the boundary of which becomes the membrane of the daughter nucleus. This stage is represented on Plate 6, fig. 40, a telophase stage of the heterotypic mitosis. While this clear space and the nuclear membrane are in the process of organization the chromosomes expand and become longer and thinner. They radiate outward across the flattened region of the reconstructing daughter nucleus. Their free ends begin to curve, and because of this curving the end of one arm of a chromosome is brought into contact with an arm of another chromosome and those ends apparently fuse together. This fussion of the end of one chromosome to another seems to form a spireme of short duration only, for it is soon transversally segmented. This is shown by the fact that in the succeeding stages, although the shape and the position of the chromosome are apparently retained, the writer failed to find a distinct continuous spireme among the sections examined. Plate 6, fig. 41, represents a stage closely following the one shown in fig. 40. The nuclear membrane is definitely formed and the daughter J- or V-shaped chromosomes are seen connected with one another by delicate strands. Still more advanced stages of the reconstructing daughter nuclei are indicated on Plate 7, figs. 42 and 43. The daughter chromosomes with somewhat ragged appearance and partially condensed are more or less evenly distributed in the nuclear cavity. The nucleus continues to grow in size and becomes rounded. The nucleolus is relatively small and frequently is hidden between the chromosomes and does not appear clearly in the daughter nucleus.

HOMŒOTYPIC MITOSIS

The succession of events during the division of the daughter nuclei is extremely rapid. The period covered from the time the nuclear membrane is formed in the late telophase, up to the reorganization of the daughter chromosomes preparatory for the second division is of short duration. The daughter nuclei appear not to pass into anything resembling a typical resting condition.

Shortly after the nucleus has sufficiently increased in size and assumed the spherical form and the chromosomes have attained a more distinct outline, the nuclear membrane breaks down and the multipolar spindle fibers appear at different sides of the nuclear cavity. The cytoplasmic materials diffuse into the nuclear cavity, while the chromosomes collect closely together, as in the previous division. The spindle fibers radiate into this mass, and each chromosome is attached at, or close to, its end by a small bundle of fibers. As in the heterotypic division, the multipolar spindle fibers become bipolars while the chromosomes become arranged in the equatorial plate. Plate 7, fig. 44, shows a polar view of the two sets of chromosomes more or less evenly distributed. There are sixteen monovalent chromosomes in each set. Like the heterotypic chromosomes they display various shapes; some of them are somewhat globular while others resemble short bent rods, but most of them are pestlelike or dumb-bell-shaped.

The two spindles may lie parallel or at right angles to each other, or in some cases in a V-shaped position. Plate 7, fig. 45, represents a side view of two spindles at the metaphase stage lying almost parallel to each other. Figure 46, on the same plate, is about the same stage as fig. 45 and shows a side view of one spindle and more or less of an oblique polar view of the other spindle. This indicates that the two spindles lie somewhat at right angles to one another. The majority of the chromosomes seem to be attached at the end or very close to it. They exhibit the same variations in shape as did the daughter chromosomes, which were observed in the equatorial plate, appearing during their separation in the heterotypic mitosis. As the granddaughter chromosomes move away from one another and proceed toward the spindle poles they become V-shaped as in the previous division, but as they approach the poles they become considerably straightened out. During this stage no fission was observed. At the poles the chromosomes draw together in a mass and become surrounded by a denser cytoplasm, which is followed by a gradual expansion and the appearance of a clear space between them. Ultimately, the nuclear-limiting membrane makes its appearance, while the chromosomes advance into a process of alveolization. Plate 7, fig. 47, represents a typical telophase stage just before the formation of the nuclear membrane and nucleolus, while fig. 48 shows one of the granddaughter nuclei after the nuclear membrane and the nucleolus made their appearance.

DISCUSSION

The series of changes preceding the development of the heterotypic spireme up to the formation of the bivalent chromosomes have been the important subject for research and debates for the last twenty-five years. Much work has been done and published on the cytology of animals and plants. Various accounts and interpretations of reduction division were offered and as a result two important theories were advanced; namely, parasynapsis and telosynapsis. Both of these theories are very conspicuous in recent literature. The parasynapsis interpretation may be said to have been initiated by the excellent work of Hans Von Winiwarter(25) and strongly supported by Gregoire,(14, 15, 16) A. and K. E. Schreiner,(23, 24) Allen,(1) Berghs,(2, 3) and others. According to this scheme the spireme consists of a double-thread system which arises by the union of homologous parental elements during the heterotypic prophase. Thus, the resulting spireme is bivalent in nature, and each of its segments is composed of two somatic chromosomes arranged side by side. The telosynaptic interpretation was advanced by Farmer and Moore,(10) and supported by Fraser,(11) Mottier,(19) Digby,(9) and others. The double-thread system in the heterotypic prophase, according to this scheme, arises by the pairing of the threads derived from the halves of the somatic chromosomes which have split by process of alveolization. Therefore, the resulting spireme from this pairing is univalent in nature, and any segment of it consists of a single somatic chromosome and the union of the paternal and maternal chromosomes takes place at the second contraction. A slight variation of this scheme, however, has been observed in *Oenothera*, by Gates,(12) Davis,(6, 7, 8) and Cleland;(5) in *Fucus* and *Cutleria*, by Yamanouchi;(26, 27) and in *Lactuca*, by Gates and Rees.(13) The spireme in the heterotypic prophase is observed as a single unsplit filament, which arises by an irregular process of condensation, and the split preparatory for the second contraction is first observed only in the heterotypic anaphase.

The foregoing description of the reduction division of *Cocos nucifera* presents strong evidence for the telosynaptic interpretation. During the early heterotypic prophase the chromatin threads are arranged in a very irregular manner and they are mostly found unpaired. Although in some cases it is possible to find threads that run closely parallel to one another for some distance, the degree of parallelism is too insignificant to amount to anything in support of the parasynaptic interpretation. This

occasional parallelism of the threads may be considered as mere chance, occurring in certain conditions as presented by *Cocos nucifera*. All my observations seem to corroborate the accounts of Gates,(12) Davis,(6, 7, 8) Gates and Rees,(13) and Cleland,(5) in which the spireme in the heterotypic prophase is said to be formed by an irregular process of condensation rather than by the union of two distinct threads.

During the later period of the synezesic contraction the chromatic knot appears very complex and the nature of the spireme is rather difficult to determine. This is the most critical period of the life-cycle of the heterotypic mitosis. The general significance of this contraction, and its relation to the changes that take place during the early heterotypic prophase, has been apparently the cause of many confusing accounts and interpretations by many investigators. The massing of the chromatin material at one side of the nuclear cavity of the mother-cell nucleus previous to the formation of the chromosomes of the first heterotypic mitosis was first observed in 1895 by Moore,(18) and he called it synapsis. Sargant,(22) in 1897, reported that she observed the same condition, not only in fixed material, but also in the living pollen mother cell of *Lilium*. Following the discovery of this phenomenon several eminent cytologists have taken a great interest in the study of synapsis in both animals and plants. Among the prominent students of synapsis may be cited the following: Allen,(1) who believes that the fusion of threads and of the chromosomes occurs very early in synapsis; Farmer and Moore,(10) who noted the long duration of this stage, the development and loosening of the spireme, and the relative increase in size of the nuclear cavity in *Lilium;* Cardiff,(4) who states that in the plants studied by him, gravity determines the position that the mass shall take; and Gates,(12) who has published an account on the hybrid of *Oenothera* and pointed out the great reduction in length and the thickening of the spireme during synezesis.

Mottier(19) made a detailed description of synapsis and contradicted the theory advanced by Cardiff; Miss Fraser (11) observed synapsis in *Humaria*, a fungus; Yamanouchi(26) described the synapsis observed in *Nephrodium*, a fern; Davis(6, 7, 8) explains the phenomenon of synapsis as due to general and slow contraction of the reticulum away from the nuclear membrane, a contraction that carries most of the strands toward the center of the nucleus; Gregoire,(14, 15, 16) whose general interpretation does not differ very much from the others,

although he believes that the pairing of the maternal and paternal elements takes place during this period of the nuclear activity; Lawsons,(17) who made a critical study of this phase of the heterotypic mitosis, believes that—

> . . . during this phase known as synapsis there is no contraction whatever of the chromatin substance, and this contraction stage has nothing whatever to do with the blending or fussion of maternal and paternal chromatin threads and consequently plays no rôle in the process of chromosome reduction.

In his concluding paragraph he states—

> My interpretation of the phenomenon known as synapsis is simply that it represents a growth period of the nucleus—a condition that is in harmony with the peculiar organization of spore-mother-cells. It is a period during which the increasing karyolymph exerts a great osmotic pressure from within. This pressure results in the extension of the nuclear cavity towards an intercellular space where there is least resistance from the neighboring cells. The chromatin mass is left behind, and its characteristic position at one side of the nuclear membrane is a perfectly natural one.

On the other hand, Gates and Rees have shown by means of a series of measurements in the growth period of *Lactuca* pollen mother cells, that in synezesis the reticulum undergoes contraction to approximately half the diameter of the resting nucleus, and that there is a steady growth of the nucleus. Their findings were corroborated by the writer's observations on *Elodea gigantea,*(20, 21) in which careful measurements on the growing period of the pollen mother cells were also made.

Recently Digby,(9) in her extensive work on *Osmunda,* has indicated that during synezesis the association of the chromatin threads derived from the telophasic split of the chromosomes during the last somatic mitosis is consummated. While Gregoire(14, 15, 16) agrees in the doubling of the spireme during the synezesic contraction, yet he believes that the pairing threads are of paternal and maternal origin. Therefore, these views seem to show that it is during the synezesic contraction when the doubling of the spireme takes place, and that this contraction is apparently the process responsible for the bringing together of the threads. In the case of *Cocos nucifera,* however, it seems that neither of the two interpretations can be applied. The early spireme appears to be distinctly single with a slightly unequal thickening in some places, while in some instances a slight parallelism is observed. But these instances are rare in comparison with the cases in which the spireme is found single. The plausible explanation for this, therefore, is the unequal condensation and contraction of the various threads of the system. During

synezesis the delicate univalent threads gradually condense into a relatively short and thick spireme which becomes arranged into as many loops as the bivalent number of chromosomes. From this fact it is evident that in *Cocos nucifera* the chromosomes of the heterotypic mitosis are not formed side by side through the parallel association of two distinct paternal and maternal elements, but are developed from a single spireme, which by segmentation forms thirty-two monovalent chromosomes arranged end to end.

Gates and Rees,(13) in their paper on *Lactuca,* state that—

> The complete loops separate in the segmentation of the spireme. Each bivalent chromosome is thus constituted from the two arms of a loop. This structure condenses greatly, and it appears that in some cases at least the torsion remains. If this account of the formation of the bivalents is true, and we can see no escape from it, the synezesis has no part in bringing about the pairing, and its significance as a unique physiological condition of the nucleus remains entirely obscure.

While the individual loops are gradually separated from each other by process of segmentation, they become short and thick and the free ends do not twist about each other, therefore true "strepsinema" does not occur in *Cocos.* The segments are distinctly single in nature and no sign of fission or splitting can be noticed. As the process of condensation proceeds the spireme passes into a second contraction, the greater portion of the spireme filaments become collected and entangled at one side of the nucleolus.

In the diakinesis stage of *Oenothera franciscana,* Cleland(5) observed the constant and uniform linking together of bivalent chromosomes which, according to him, is—

> . . . a penomenon which can hardly be explained on a parasynaptic basis; and, the most reasonable explanation seems to be that the bivalent chromosomes represent sections of the spireme which occupied such a position in the nucleus that, when the whole system became condensed, the chromosomes found themselves linked in this very definite way.

In the diakinesis of the mother cells of *Cocos nucifera* a more or less similar linking of the chromosomes is observed; this is strong evidence for the end to end arrangement, or telosynaptic interpretation.

SUMMARY

The chromatin reticulum in the resting stage of the pollen mother nucleus of *Cocos nucifera* Linnæus is granular in character and is evenly distributed in the nuclear cavity.

In the early heterotypic prophase the chromatin threads are arranged in a very irregular manner and in them there is a very slight parallelism.

The synezesis is brought about by the contraction of the reticulum, accompanied by a rapid growth of the nucleus. The spireme is formed by an irregular condensation of the chromatin threads and appears at this stage single and unsplit.

Following the long period of synezesic contraction the univalent unsplit spireme gradually spreads throughout the nuclear vacuole and forms loops equal to the gametic number of the chromosomes.

Soon after the spreading of the spireme it passes into a second contraction, and this process is followed by the gradual separation of the loops from one another by segmentation.

Each loop consists of two monovalent chromosomes arranged end to end.

While the segments emerge from the second contraction they undergo considerable condensation and become shorter and thicker.

The thickened segments at the early diakinesis stage appear like J's, O's, X's, Y's, and U's, while in the later stages some of them simulate dumb-bell-shaped bodies, and still others, straight and bent rods.

There are sixteen bivalent chromosomes, and in some instances, due to overlapping, there are fifteen. One of the chromosomes is strikingly larger than the others, while three of the chromosomes are smaller.

The multipolar spindle appears after the dissolution of the nuclear membrane and nucleolus.

At the metaphase stage the bivalent chromosomes are arranged more or less evenly and symmetrically in one plane.

All the sixteen bivalent chromosomes split lengthwise at the same time, and as the daughter chromosomes move toward the two poles they take on the V- or the J-shape, with apex toward the poles.

The splitting, or fission, is observed only at the late telophase stage during the formation of the nuclear membranes of the daughter nuclei.

The daughter nuclei resulting from the first division do not pass into anything resembling a typical resting condition. They soon reorganize and prepare for the homœotypic division.

As the nuclear membranes and the nucleoli of the daughter nuclei disappear, the two homœotypic spindles make their ap-

pearance simultaneously. The univalent chromosomes proceed to the two equatorial plates and split lengthwise equally to form the four granddaughter nuclei.

I wish to express my appreciation and gratitude to Miss Maria D. Pastrana for some of the material used, and to Mr. Demetrio Andres, who assisted me in the collection of the material from San Pablo, Laguna.

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ILLUSTRATIONS

[All figures were drawn with the aid of a camera lucida under the Spencer 1.5 mm. N. A. I. 1.30 apochromatic objective in combination with Carl Zeiss K 20 ocular and Carl Zeiss Orthoskop-Ockular 28x, giving a magnification of 4,100 and 5,500 diameters, respectively. The drawing were reduced to two-thirds in the reproduction.]

PLATE 1. COCOS NUCIFERA LINNÆUS

FIG. 1. A resting nucleus in pollen mother cell, showing a single large nucleolus and the uniformly distributed delicate threads with nodelike chromatic thickening. × 2733.

2. A pollen mother-cell nucleus entering into early prophase; note the irregular thickening of the threads in the reticulum. × 2733.

3. A definite stage of the heterotypic prophase. The reticulum is more defined, consisting of fine threads with irregular thickening and nodelike chromatic granules at the junction of the meshes. × 2733.

4. The beginning of the synezesic contraction and early stage of the spireme; note its irregular thickening. × 2733.

5. A portion of a superficial section of a nucleus entering into synezesic contraction in the same stage as fig. 4. × 3666.

6. A more-definite stage of early synezesis, showing the gradual withdrawal of the early spireme from the nuclear membrane. × 2733.

7. A superficial section of a nucleus in the same stage as fig. 6, showing the unsplit and univalent character of the spireme. × 3666.

8. An early stage of synezesis. The unilateral massing of the chromatin threads is more conspicuous and the meshes are greatly reduced in size. × 2733.

PLATE 2. COCOS NUCIFERA LINNÆUS

FIG. 9. A more-advanced synezesic contraction; the threads and the meshes are drawn into a close mass. A portion of the spireme is extending across the nuclear cavity to the nuclear membrane. × 2733.

10. The appearance of the spireme at the complete synezesic contraction. × 2733.

11. A thin tangential view of the synezesic knot in the same stage as fig. 10, showing the hazy outline and the spiral twisting of the spireme. × 3666.

12. The univalent spireme emerging from the synezesic knot; note the delicate fibers connecting the loops to the nuclear membrane. × 2733.

13. The loosening of the spireme from the synezesic knot and the formation of loops is well underway. The spireme appears more distinct and uniform in character. ×2733.
14. A segment of a superficial section in the same stage as fig. 13. × 3666.
15. An early stage of the hollow spireme; note the loops extending toward the periphery of the nuclear cavity and the well-defined and more-uniform outline of the spireme. × 2733.

PLATE 3. COCOS NUCIFERA LINNÆUS

FIG. 16. A complete hollow spireme. × 2733.
17. A later stage of the hollow spireme; the loops are shortening and the sides of each loop are brought close together while the segmentation begins to take place. × 2733.
18. Slightly older stage than the one shown in fig. 17. The approximation of the sides of each loop and the segmentation are more evident. × 2733.
19. Early stage of the second contraction. × 2733.
20. A complete second contraction. × 2733.
21. The bivalent segments coming out from the second contraction, which are greatly thickened and shortened. × 2733.

PLATE 4. COCOS NUCIFERA LINNÆUS

FIG. 22. The bivalent segments after the second contraction. × 2733.
23. Early diakinesis stage. The bivalent segments are under the process of condensation and assume different configurations. × 2733.
FIGS. 24 and 25. Slightly older, two similar stages, showing the U-, Y-, J-, O-, and V-shaped chromosomes. × 2733.
26*a* and 26*b*. The two halves of the pollen mother-cell nucleus with sixteen bivalent young chromosomes. × 2733.

PLATE 5. COCOS NUCIFERA LINNÆUS

FIG. 27. A tangential section of the nucleus, a slightly older stage than fig. 26, showing the X-, O-, Y-, and V-shaped chromosomes. × 2733.
28. Three bivalent segments in the same stage as fig. 27 under higher magnification. × 3666.
29. A tangential section of the nucleus showing the appearance of the bivalent chromosomes after a greater condensation; shortening and thickening have taken place. × 2733.
FIGS. 30 and 31. Two diakinetic stages, one closely following the other. The bivalent chromosomes appear as dumb-bell-shaped and as straight and bent rods. × 2733.
32 and 33. Another two successive stages of the late diakinesis, showing the formation of the multipolar spindle fibers. × 2733.
FIG. 34. Spindle fibers becoming bipolars and the bivalent chromosomes are moving toward the equatorial region. × 2733.

PLATE 6. COCOS NUCIFERA LINNÆUS

FIG. 35. A polar view showing the sixteen bivalent chromosomes at the equatorial plate. × 3666.

36. Side view of the metaphase of the first division. × 3666.

37. Typical side view of anaphase in which the daughter chromosomes are mostly V- and J-shaped with apex of V and J attached to the spindle. × 3666.

38. Early telophase of the heterotypic mitosis. × 3666.

39. A somewhat oblique polar view of the same stage as fig. 38. The daughter chromosomes are mostly V-shaped. × 3666.

40. A typical heterotypic telophase, showing the elongation of the daughter chromosomes, their splitting, and the formation of the clear spaces between them. × 3666.

41. A later stage of one of the daughter nuclei in the heterotypic telophase after the appearance of the nuclear membrane. × 3666.

PLATE 7. COCOS NUCIFERA LINNÆUS

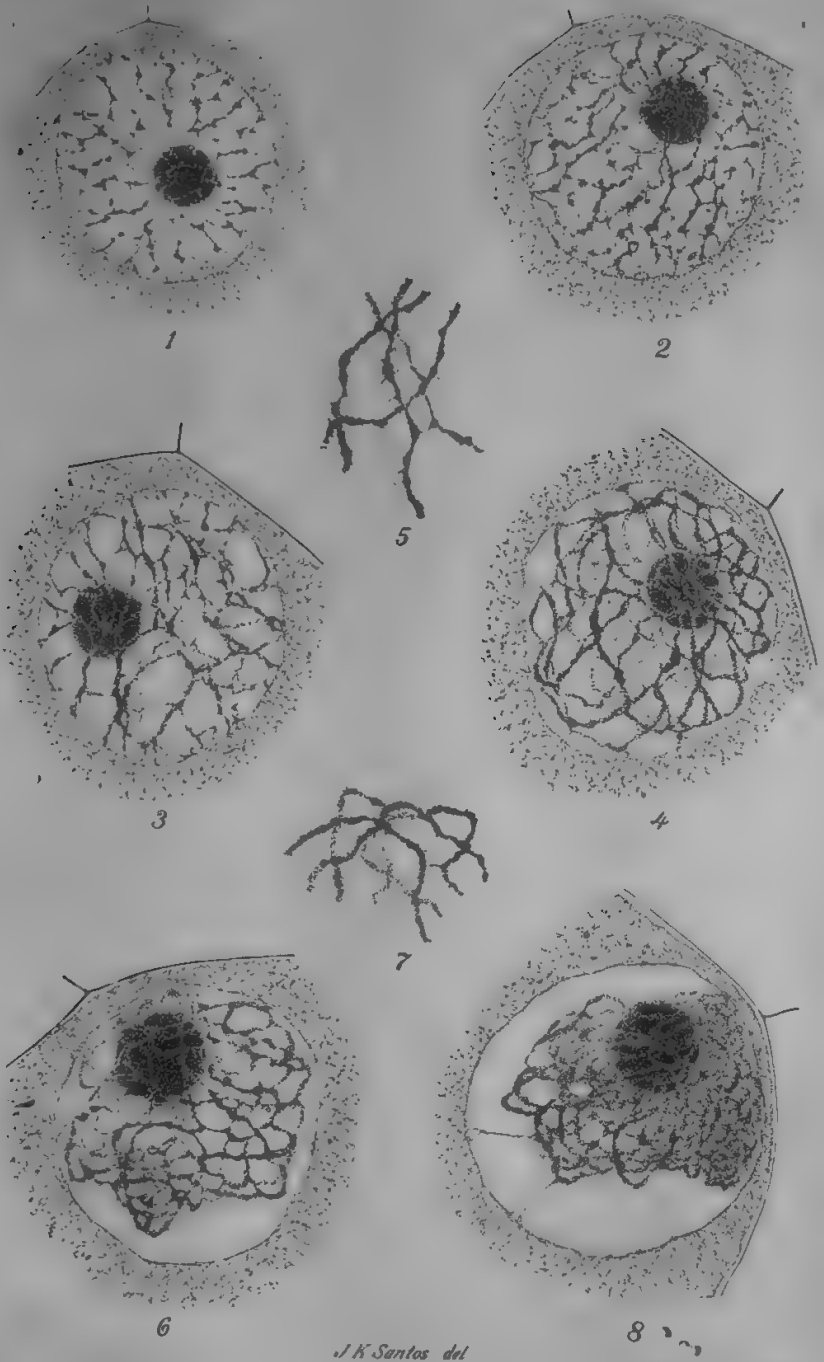
FIGS. 42 and 43. Two stages of one of the daughter nuclei, indicating the very irregular shape of the daughter chromosomes apparently going to resolve, but remaining more or less in this condition for a short period and not passing to true resting stage. × 3666.

FIG. 44. A polar view of the daughter chromosomes at the metaphase stage of the homotypic mitosis. × 2733.

FIGS. 45 and 46. Two views of homotypic metaphases. × 2733.

FIG. 47. A homotypic telophase, showing the side view of the future granddaughter nuclei. × 2733.

48. A granddaughter nucleus after the appearance of the nuclear membrane and the nucleolus. × 3666.



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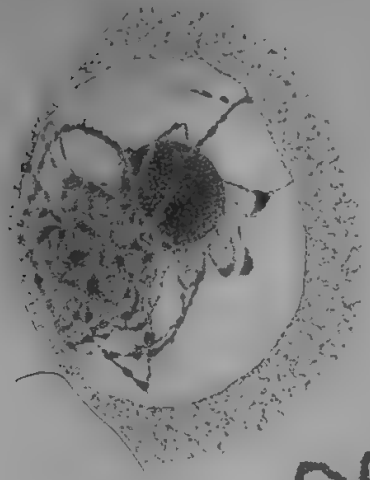

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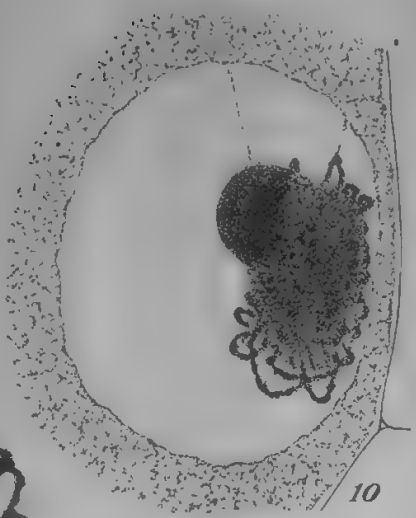

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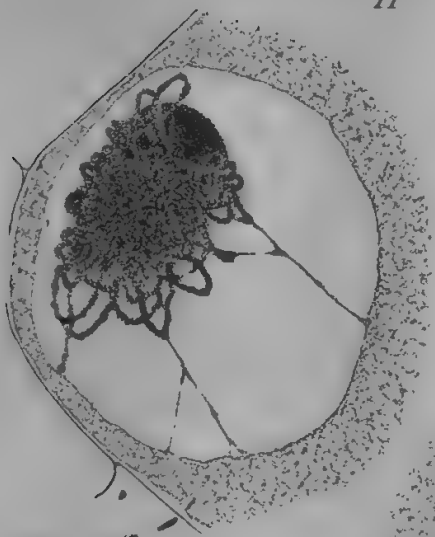

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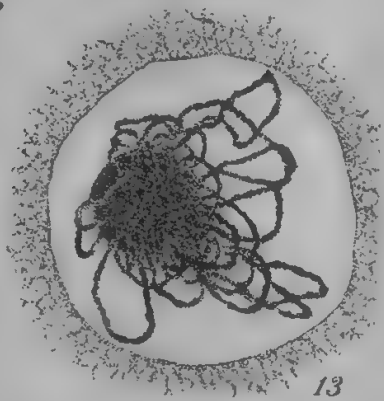

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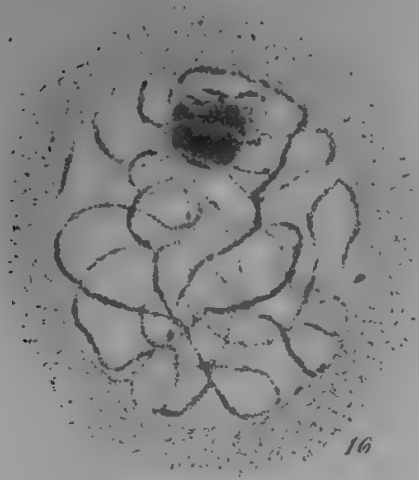
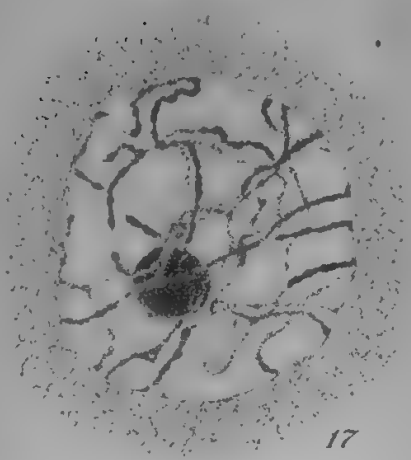
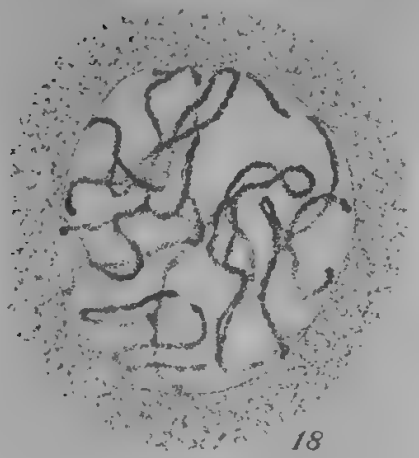
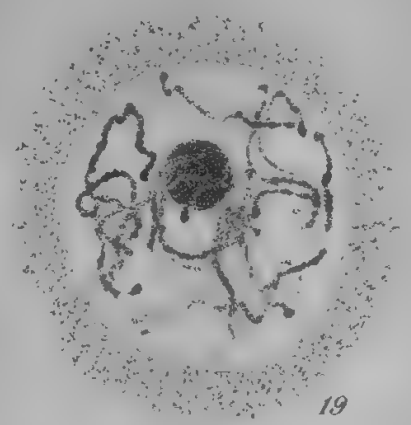
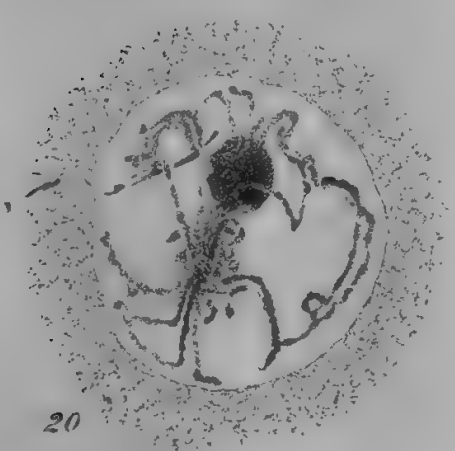
PLATE 2.

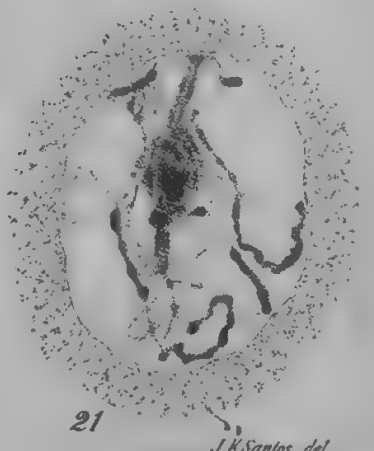












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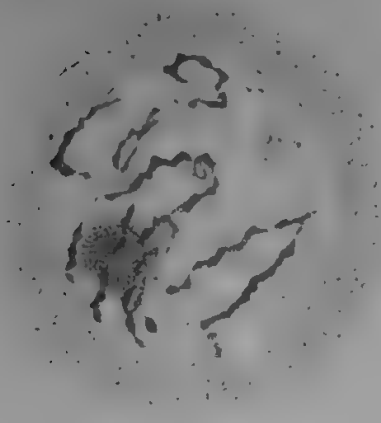

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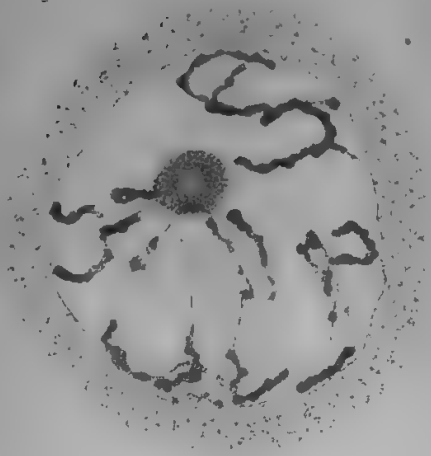

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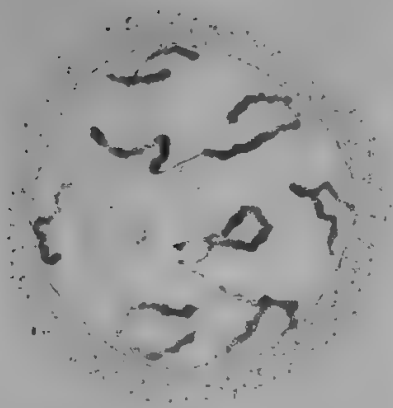

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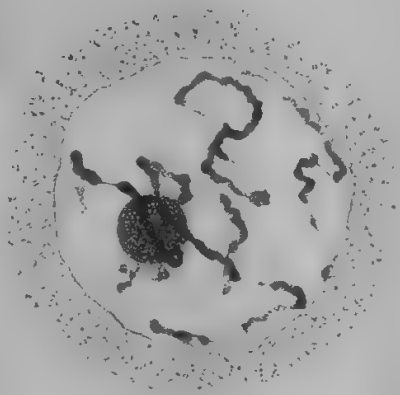

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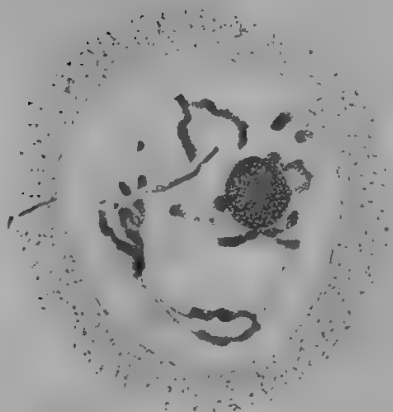

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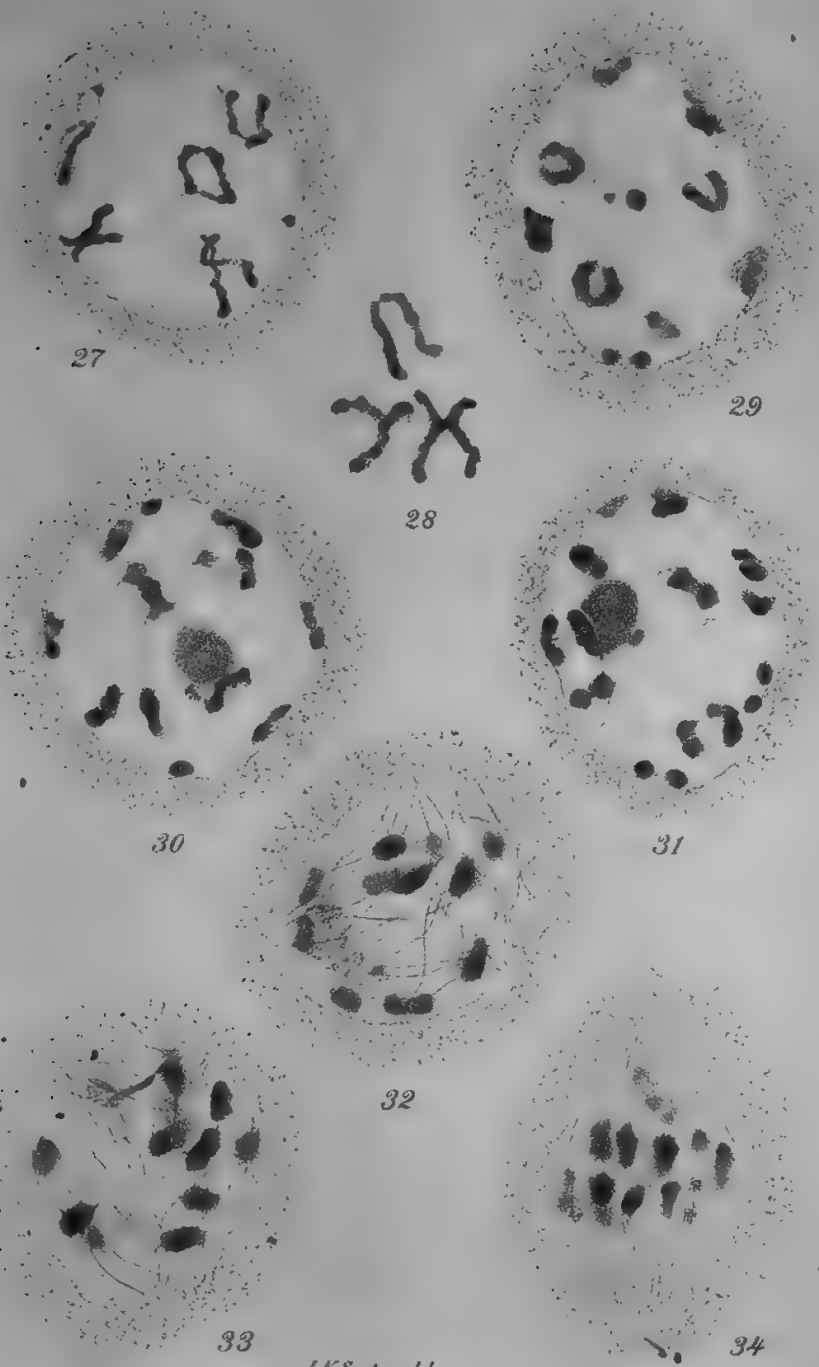
PLATE 4.



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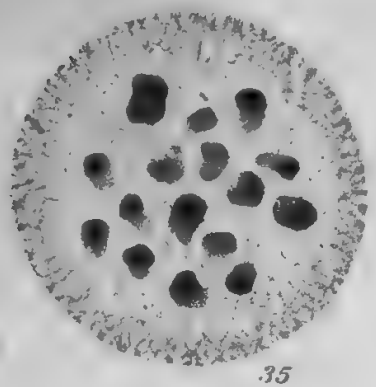

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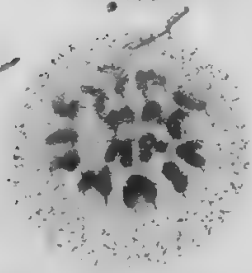

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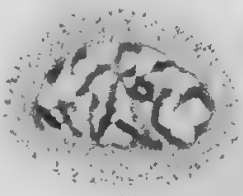

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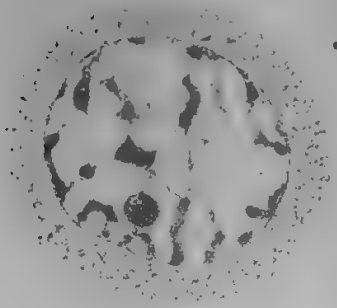

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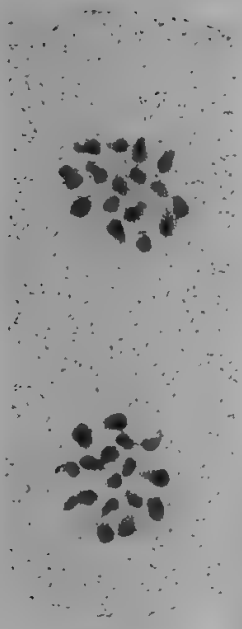

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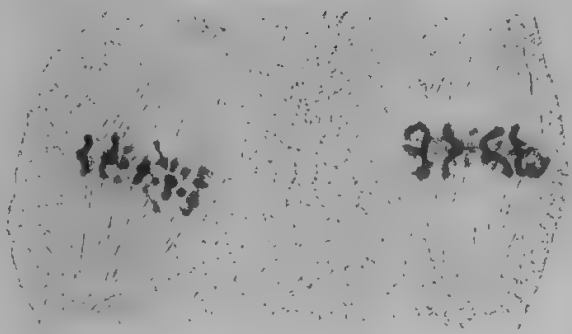

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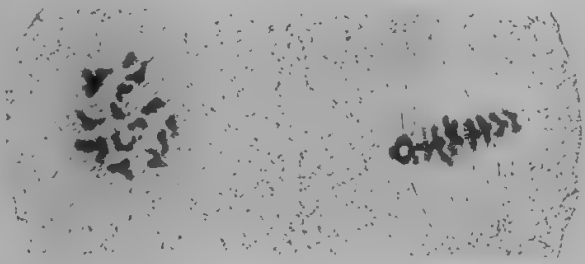

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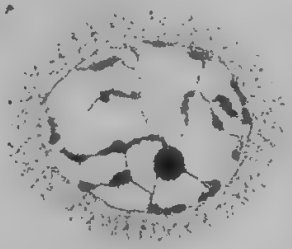

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